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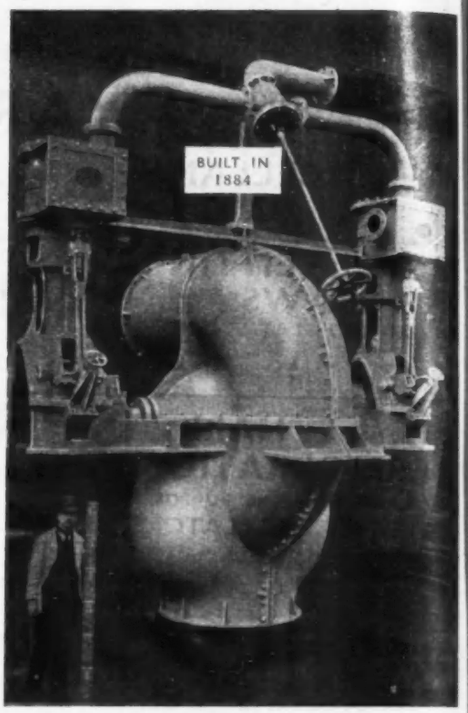

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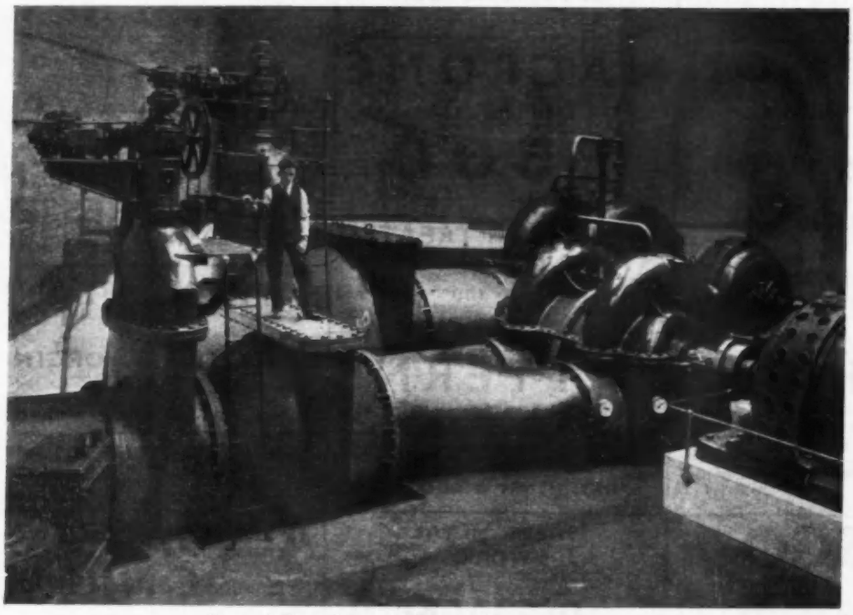

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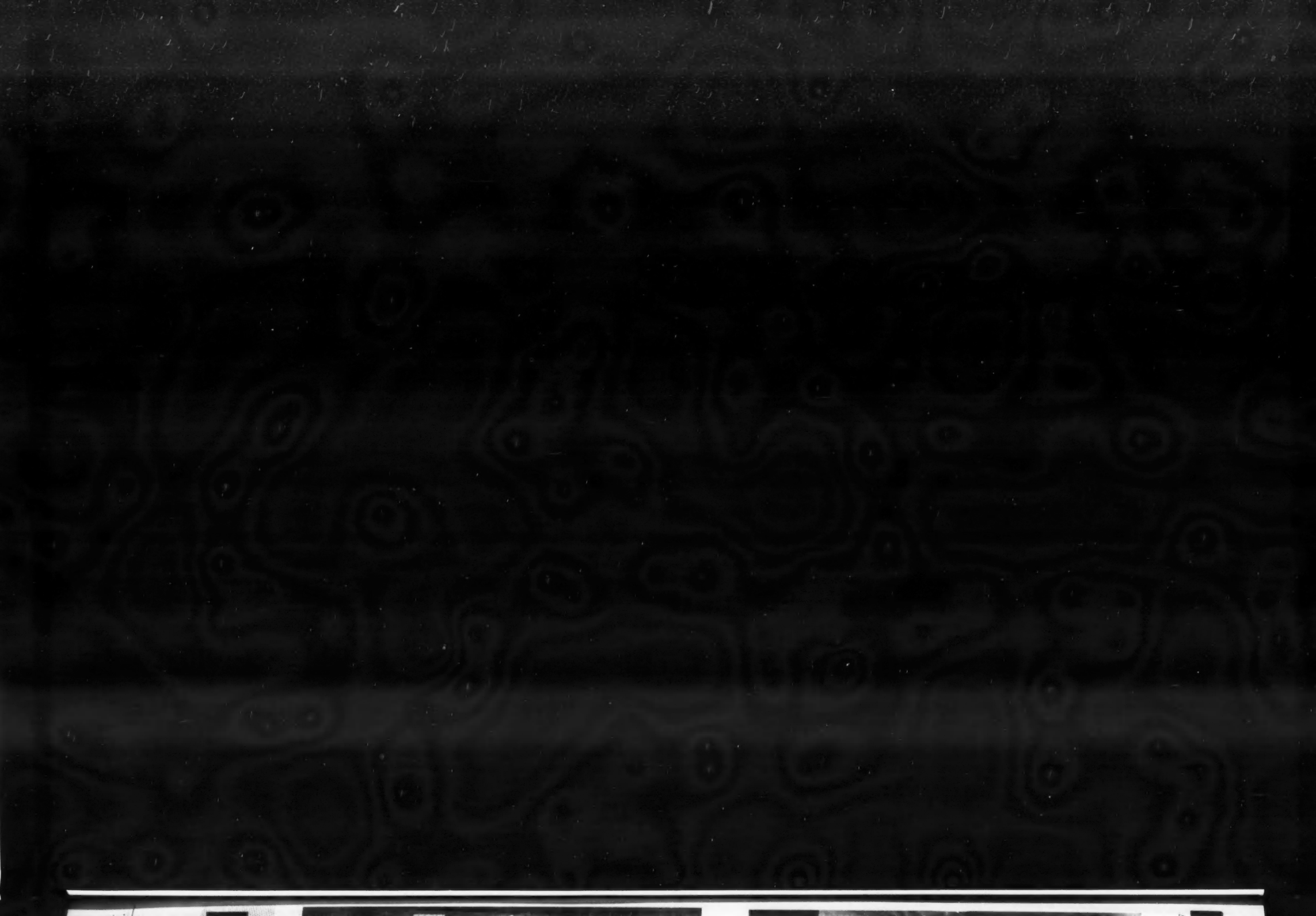


THE CLAYTOR HYDRO-ELECTRIC POWER PLANT.

THE Claytor dam which has been built across the New River in Virginia, by the Appalachian Electric Power Company, is of particular interest in view of the nature of the site and the elaborate grouting and foundation-consolidation work which had to be carried out. The Appalachian Electric Power Company is owned by the American Gas and Electric Company and constitutes the central supply system of the latter. It operates over a large area in Virginia and West Virginia and extends into Ohio, north of the Ohio River. The new plant, which is situated about four miles south of the city of Radford, is the third development carried out by the company on the New River. The others, at Buck and Byllesby, are situated farther upstream. The Claytor plant consists of four 26,000 h.p. Francis turbines, driving 11,000-volt three-phase generators. The whole output of the station is stepped up to 132,000 volts by two banks of transformers. These are connected to the transmission lines between Roanoke, Virginia, and Glen Lyn in the same State. The plant at the latter place is one of the larger steam installations of the system.

The basin which drains to the Claytor dam has an area of 2,400 square miles and the average river flow at the site, over the period 1907 to 1930, was 3,280 cusecs. The tracks of the Norfolk and Western Railroad cross the river at the point at which the upper end of the reservoir formed by the dam is now situated, and in view of this the maximum height of the impounded water was fixed at El. 1,846. This is about 115 ft. above the previous average level of the river and gives a storage capacity equivalent to 12,000,000 kWh between top elevation and the lowest level at which the plant can be operated economically. The average quantity of water available annually was estimated to be equivalent to an output of 190 million kWh., the figure for the best years being 400 million and for the worst 110 million.

The dam, a general view of the downstream face of which is given in Fig. 1, on this page, is a gravity type structure. It lies roughly north and south, the power house, on the left in Fig. 1, being at the south end. The total length of the structure is 1,142 ft., made up of a southern solid section or bulkhead 218 ft. long; the power house 176 ft. long; a 22 ft. 6 in. trashway; nine spillway bays of a total length of 539 ft. 6 in.; and a north bulkhead 186 ft. long. These various parts of the dam are clearly shown in the downstream elevation and plan given in Figs. 2 and 3, on pages 422 and 423. Sections through the power house and spillway are given in Figs. 4 and 5, on page 423. The spillway crest is at El. 1,818·5 and each of the nine gates is 50 ft. wide and 28 ft. 6 in. high. When fully open they can pass a flood flow of 246,000 cusecs and retain head-water level at El. 1,846. The heaviest flood recorded during a period of 35 years was 165,000 cusecs. The floor of the power house is at El. 1,759 and the turbines normally operate under an effective head of 110 ft. They are supplied through 16 ft. dia. steel-plate penstocks. As shown in Fig. 3, the draught tube outlets from the turbines are set at an angle in order to deflect the flow into the main central channel of the river.

The geological formation at the site of the dam consists of limestone below the river bed, changing to dolomite under each of the banks. The bedding planes are in most cases almost vertical and were filled with clay to a considerable depth. Seams and channels were found throughout the area, some clay-filled and others open. In view of this broken formation, it was decided to form a tight ground cut-off below the site of the dam structure and to continue it into each abutment. The work was started by driving a series of 3-in. dia. holes into the foundation immediately upstream of the upstream face of the dam. These were first drilled at 12-in. centres, but later holes were made at 9 ft., 6 ft. and 3 ft. centres. In some places where bad underground conditions were found intermediate holes were drilled at less than 3 ft. centres. The holes were carried to a depth of 200 ft. and were filled with grout to refusal at a pressure of 200 lb. per square inch. To relieve any uplift pressure which might have developed owing to leakage through this grouted cut-off, a row of 3-in. holes, 45 ft. deep, was drilled downstream.

When the foundation area was exposed, some sections were found to be crossed, both longitudinally and transversely, by clay-filled seams. Exploratory drilling revealed, in addition, clay-filled pockets and seams at relatively shallow depths. Where possible, the clay was directly cleaned out, it being made accessible by excavating the overlying rock. When this was impracticable, it was removed by water jets and by cross-washing between drill holes. When the clay had been cleared away, the openings were filled with concrete, or grouted under pressure. In some cases the rock foundation had to be consolidated, by grouting, in order to increase the bearing strength, and much blanket grouting had to be carried out upstream of the dam face, before the cut-off curtain could be satisfactorily drilled and grouted. The acceptance of grout by the rock foundation was very high, at the north bank averaging as much as 1·88 cub. ft. per linear foot of 3-in. hole. In view of this, in order to keep grouting costs within reasonable limits, the experiment of adding minus-100 rock fines to the cement was tried. It was found that an entirely satisfactory grout could be produced by using one part of cement with two parts of minus-100 rock fines. No difficulty was experienced in pumping this material.

On the south bank of the river, conditions in general were found to be fairly satisfactory, but investigation revealed a nearly vertical clay-filled solution channel, about 12 ft. wide, lying parallel to the river and situated some 100 ft. south of the dam site. It extended to about 30 ft. below the river bed. It was sealed-off by excavating the clay and building a concrete plug across the channel. This was carried up above the maximum reservoir level. The situation was much more difficult on the north bank. In some places the rock was so badly folded and twisted that it was almost impossible to follow its geological structure. The ground-water gradient was very flat, being only 30 ft. above river level at a point 300 ft. from the bank. Exploratory drilling showed the rock to exist in a pinnacled form with the clay overburden varying in depth from zero to 70 ft. As uncertainty was felt regarding the effectiveness of attempting to consolidate the clay by chemical injection, it was decided to construct a cut-off through the overburden.

This work was carried out by forming a timbered trench, 325 ft. long, and excavated to rock level. This was then filled with sand-asphalt mortar to form a cut-off, as shown in Fig. 6 on page 423. The excavation of this trench showed that the deepest rock was as much as 150 ft. below the surface, not 70 ft. as had been suggested by the exploratory drilling. The formation of the cut-off by filling the trench either with concrete or with screened and consolidated clay was considered, but the sand-asphalt was chosen as it had the permanent tightness of poured concrete and the flexibility of clay and cost less to place than either of them. The mixture used consisted of 88 per cent. of sand, and 12 per cent. of asphalt on a weight basis. The materials were separately pre-heated and were again heated to 400 deg. F. at the mixing plant. The mix was deposited in the trench at a temperature of not less than 250 deg. F. It spread into open seams, filled all spaces at the back of the sheeting, and was forced into any horizontal passages, making an entirely satisfactory seal. The rock below the trench was consolidated by drilling and grouting before the sand-asphalt was run into place.

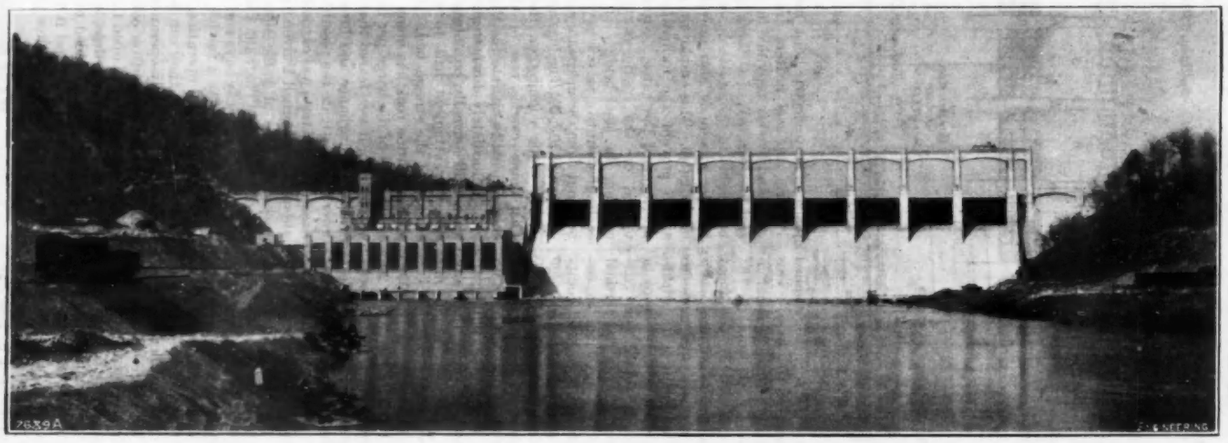


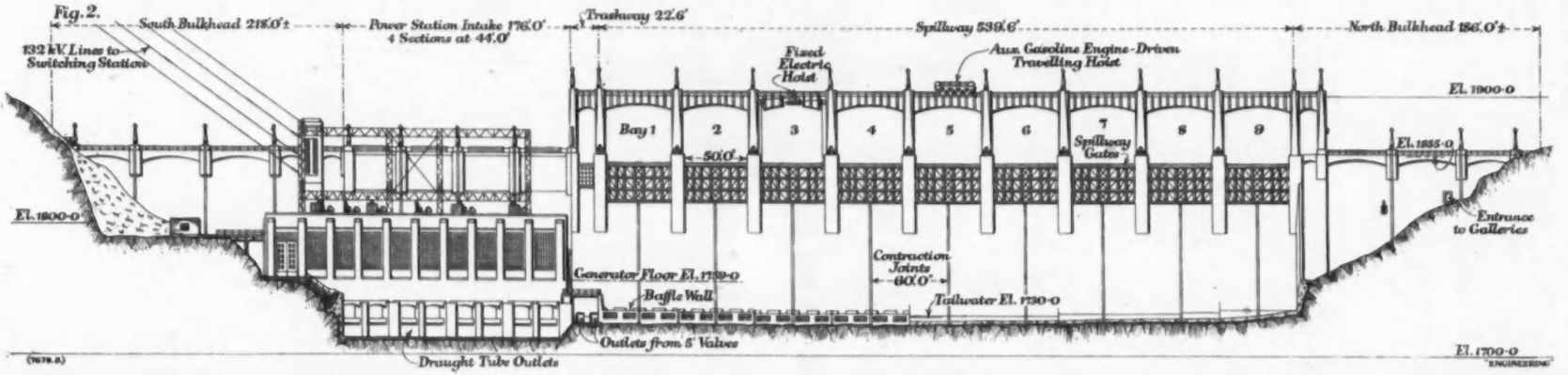
FIG. 1. DOWNSTREAM FACE OF COMPLETED DAM.

Prior to the decision to construct the dam, a dolomite quarry had been opened immediately downstream of the site. This was in full operation in 1937 when the work on the dam was put in hand. It was accordingly purchased in order to protect the site and to furnish construction space, and also with the idea of using it for the production of aggregate for the concrete work. The quarry had been engaged on the manufacture of coarse aggregate for road metal and railway ballast, but investigation showed that it could produce good stone-sand. This was of importance since no natural sand was available within a radius of 200 miles of the dam. The whole of the aggregate used, both fine and coarse, was produced from the dolomite limestone of the quarry. As but little information was available on the use of stone sand, a concrete laboratory was set up at the site. The investigations showed that excellent concrete could be produced by correctly proportioning the various aggregates produced.

The dam was built between cofferdams, work

THE CLAYTOR HYDRO-ELECTRIC POWER PLANT, VIRGINIA, U.S.A.

Fig. 2.



being carried out from the two banks simultaneously. Two of the spillways were left open, between their abutments, during the final stages of the work, the sills being carried to such a height that they were not overtopped at normal river flow. They were completed behind steel gates, the reservoir being permitted to fill gradually. The concrete was laid in sections 60 ft. wide for the spillway, 54 ft. wide for the bulkheads, and 44 ft. wide for the intake. These sections were at first built up in blocks, but difficulty was experienced owing to longitudinal cracking, parallel to the axis of the dam. On account of this various types of longitudinal construction joints were tried between the blocks, the upstream-downstream lengths of which were decreased. Reinforcing steel was also introduced above and below the construction joints with the idea of preventing cracks from extending up through the structure. These arrangements were not entirely successful and for the later stages of the work the longitudinal joints were eliminated by laying each 60 ft., 54 ft., or 44 ft. section monolithically for the full thickness of the dam. The maximum length of these sections, at the base, was 103 ft. The height of the first four lifts, above rock foundation, was limited to 2 ft. 6 in., but above these 5 ft. lifts were poured. In general, two days were allowed to elapse between the pouring of the 2 ft. 6 in. lifts and four days between the 5 ft. lifts.

The dam was designed as a gravity-type structure on the assumption that the concrete forming it would have a weight of 154 lb. per cubic foot. The concrete actually produced had an average weight of 157 lb. per cubic foot. In view of the complicated underground formation, uplift was estimated on an elaborate basis. An irregular gradient between head-water and tail-water was assumed, an allowance was made for the effect of the pressure-relief drains, and it was postulated that varying proportions of the area of the base would be subjected to uplift. As a result of the calculations, the uplift was taken to vary on a straight-line basis from maximum head-water pressure at the heel to maximum tail-water pressure at the toe, applied over 50 per cent. of the area of the base. This assumption is more conservative than is usual in calculations for dams. The ice pressure on the upstream face was taken as 10,000 lb. per linear foot applied one foot below the maximum water level in the reservoir. An attempt was made to check the development of water pressure within the concrete structure by arranging water stops in all the horizontal construction joints and connecting them to vertical water stops in the vertical contraction joints. Drains were provided downstream of the water stops in the horizontal joints and were connected by vertical pipes to the drainage tunnels. These arrangements are shown in Fig. 5. As is shown in Fig. 4, the substructure of the power house was built as an independent unit, and has no structural connection with the intake bulkhead. This arrangement was adopted in order that any movement taking place in the dam would not result in cracking in the power-house structure.

The dam was put into service on August 1, 1939, and has operated under full head since April 20, 1940. It has been mentioned already that records covering a period of 35 years showed the heaviest flood on the New River to be equivalent to a flow of 165,000 cusecs at the site of the dam. This figure was exceeded within a year of the completion of the dam, and in August, 1940, a flood giving a flow of 200,000 cusecs was experienced. A view of the spillway during the passage of this flood is given in Fig. 7, on page 424. The spillway, as mentioned earlier, is designed to handle a flood flow of 240,000 cusecs. Each of the nine bays of the spillway is 50 ft. wide and is controlled by a modified Broome-type gate 28 ft. 6 in. high. These are operated by 150-ton electric hoists located centrally between the girders of the steel bridge which spans the spillway and is well shown in Figs. 1 and 7. Push-button control for these hoists is provided both from the bridge and from the hoist-housings. For emergency operation, two portable petrol engines are provided. These can be connected to take the place of any electric-hoist motor which may fail. Electric side-seal heaters are installed on all the gates and five are provided in addition with bottom-seal heaters, so that there is no danger of not being able to operate the gates in heavy frosts. A bubbler system is also provided in front of each of the gates. This employs a stream of compressed air to prevent the formation of ice immediately upstream of the gates. Grooves for stop-logs are formed on the inside of the concrete columns carrying the steel bridge. Nine sets of stop-logs, each sufficient to close one bay, are stored on brackets built out from the upstream side of the bridge. This is shown in Fig. 5. The logs are handled by a 15-ton gantry crane running on the top of the bridge. This crane carries one of the emergency petrol engines used to operate the Broome gates.

As immediately downstream of the dam the tail-water will normally be only about 6 ft. deep, considerable attention had to be given to possible erosion of the stream bed. As already explained, the foundation rock has many clay-filled seams and as the rate of discharge per linear foot of the spillway is high, it was feared that the conditions might result in disturbance and break-up of the bed. In order to investigate the possible effects, an extensive series of model tests was carried out in the hydraulics laboratory of Cornell University. As a result of this work, the type of baffle shown in Figs. 2 and 5 was decided on. The baffles are carried across the whole of the spillway bays and not only half-way, as shown in Fig. 2. As a further means of preventing scour, the electrical operation of the spillway gates is arranged so that they can be lifted only 1 ft. at a time. Electrically-operated indicators are installed at the push-button control stations. These enable the operators to open the gates in accordance with a prescribed schedule, which is arranged so that no gate can be opened until there is sufficient depth of tail-water behind it to check the velocity of the issuing water and thus prevent erosion of the river bed.

(To be continued.)

THE CONTROL OF IRON AND STEEL.—The Minister of Supply has issued the Control of Iron and Steel (No. 16) Order, 1941, which came into force on November 12. The Order extends the control to all types of springs, but no authority or licence is required for their acquisition, except in the case of laminated or coil springs, containing either round rod—not less than $\frac{1}{4}$ in. in diameter—or other ferrous material of a corresponding cross-sectional area. Copies of the Order may be obtained on application to H.M. Stationery Office, York House, Kingsway, London, W.C.2.

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THE IMPORTANCE OF TRANSHIPMENT LICENCES.—The failure to comply with licensing requirements in respect of goods brought from abroad for transhipment at United Kingdom ports is causing unnecessary delay and impeding work at the ports. The Board of Trade points out that licences issued by the Import Licensing Department are required, not only for nearly all imports, but also for cargoes—with exceptions—brought to United Kingdom ports and entered with the Customs as in transit or for transhipment elsewhere. The exceptions are live quadruped animals, goods remaining on board for onward carriage in the same ship, and ships' surplus stores transferred—under Customs transhipment regulations—to other ships for use as stores. Goods requiring licences but arriving without them are liable to seizure. Applications for such licences should be made before the shipment of cargoes and must be made by a firm or individual resident in the United Kingdom. Further details and forms of application in respect of transhipment cargoes are obtainable from the Import Licensing Department, Board of Trade, 1-6, Tavistock-square, London, W.C.1.

THE CLAYTOR HYDRO-ELECTRIC POWER PLANT, VIRGINIA, U.S.A.

THE CLAYTOR HYDRO-ELECTRIC POWER PLANT, VIRGINIA, U.S.A.

(For Description, see Opposite Page.)

Fig. 3.

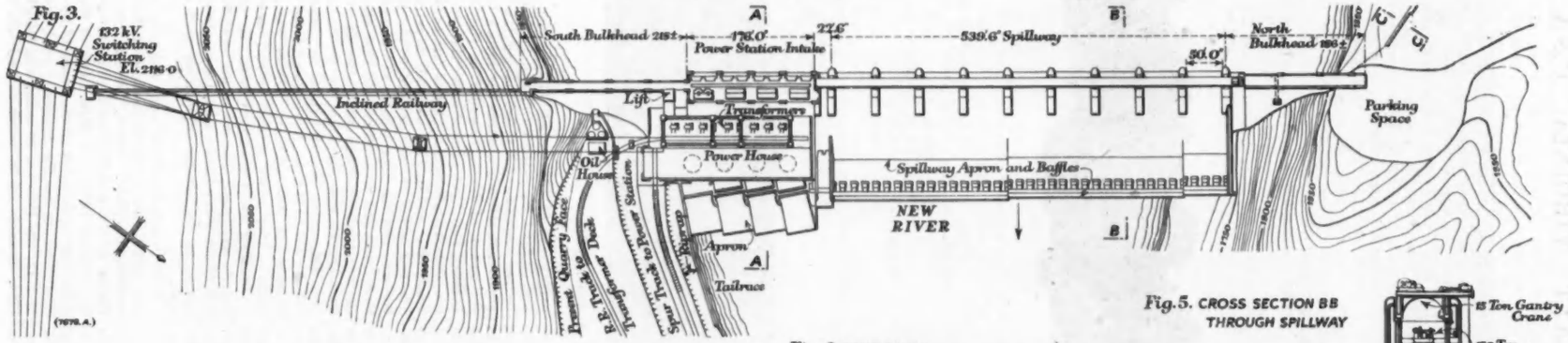


Fig. 4. CROSS SECTION AA THROUGH POWER HOUSE & INTAKE

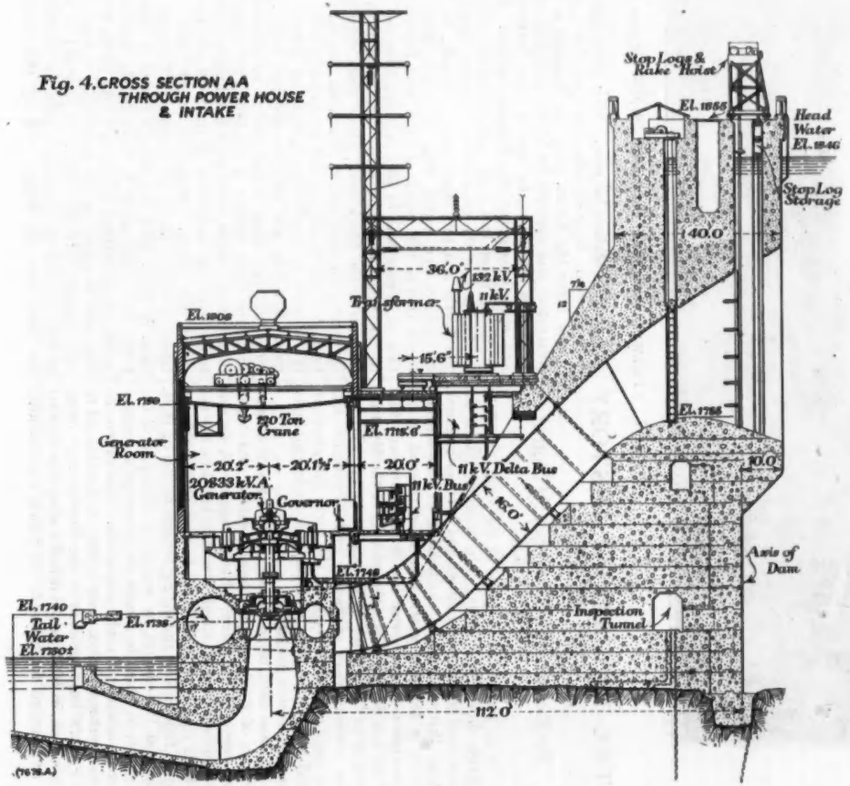
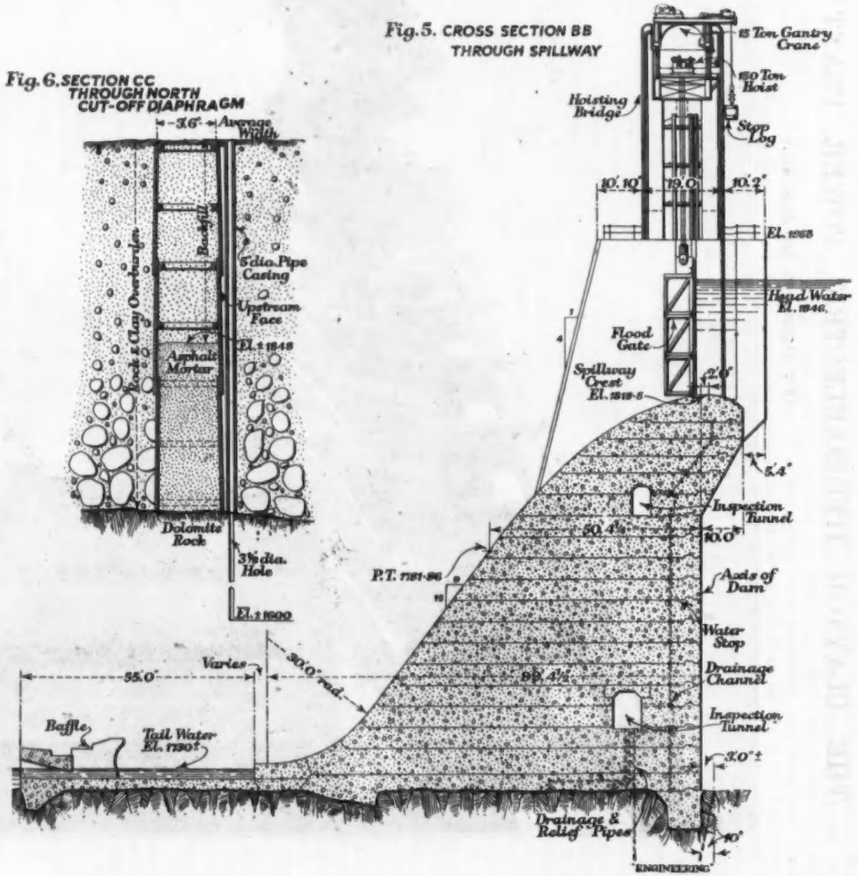


Fig. 6. SECTION CC THROUGH NORTH CUT-OFF DIAPHRAGM

Fig. 5. CROSS SECTION BB THROUGH SPILLWAY



THE CLAYTOR HYDRO-ELECTRIC POWER PLANT, VIRGINIA, U.S.A.

(*For Description, see Page* 421.)

FIG. 7. SPILLWAY PASSING A FLOOD OF 200,000 CUSECS IN AUGUST, 1940.

THE INDUSTRIAL HISTORY OF RUSSIA.

By ENGINEER-CAPTAIN EDGAR C. SMITH, O.B.E., R.N.

IN an inconspicuous place at the west end of the parish church of Spalding, Lincolnshire, stands the memorial to the naval officer and harbour engineer, John Perry, who died at Spalding on February 13, 1732, in his 63rd year. The chief interest in the inscription on the stone lies in the statement that "He was Several Years Comptroller of the Maritime Works to Czar Peter in Russia." Perry, who was the contemporary of Savery and Newcomen, was an engineer of the type of the early Smeatonians, and was the first harbour engineer to be employed in the Russian Empire.

He was born in 1670, one of the sons of Samuel Perry, of Rodborough, Gloucestershire, and began his career in the Navy. By the age of 20, he was a lieutenant and through a wound had lost the use of his right arm. In 1693, having been employed some time in superintending repairs to one of H.M. ships at Portsmouth, he was given command of the Cygnet, in which he fought an unsuccessful engagement against French privateers. Thereupon he was court martialled, fined 1,000*l.*, and sentenced to ten years' imprisonment in the Marshalsea. From the prison, in 1694, he published a pamphlet entitled "Regulations for Seamen," in which was included an appendix stating his case. Soon afterwards, he was released. In 1698, when the Czar Peter, afterwards Peter the Great, came to England seeking instructors and artisans for his shipbuilding yards, Perry was introduced to him by Lord Carmarthen and agreed to enter the Russian service. From boyhood, Peter had built and handled boats and he dreamed of the time when his ships would sail the Baltic and the Black Sea. Already, in 1696 his galleys had sailed from Voronezh down the River Don to the attack of Azov, and Perry's first task in Russia was to plan a canal from the Don to the Volga, whereby ships could pass from the Caspian to the Black Sea. Three years were spent by him in the province of Astrakhan, the summers being devoted to surveys and preliminary work, and the winters to ineffectual appeals for money and men. The long war with Sweden had begun, and for a time the canal project had to be abandoned. From the lower reaches of the Don, Perry was sent to Voronezh, where small craft had long been built, to improve the navigation of the river and to construct dry docks. Altogether, eight years were taken up with work in the vicinity of Voronezh and then, in 1709, after the famous battle of Poltava, Perry was called north to examine the waterways in the neighbourhood of the new city of St. Petersburg and to report on the possibility of connecting Lake Ladoga with the Volga. A year or two later, he was ordered to examine a plan for connecting the Neva and the Volga; but by this time his experiences of Russian life and Russian methods had damped his enthusiasm, and he declined any further engagement. Peter having taken up an unpleasant attitude towards the British because of the arrest of his ambassador in the streets of London, Perry put himself under the protection of the British ambassador, Charles (afterwards Lord) Whitworth, and in 1712 was able to return home. The rest of his life was devoted to the surveys of harbours and the improvement of waterways. His most important undertaking was that described on the memorial, which adds that, after his return from Russia, "he was Employed by y^e^ Parliament to stop Dagenham Breach which he Effected and thereby Preserved the Navigation of the River of Thames and Rescued many Private Familys from Ruin." Just before he died he had been engaged in draining the Lincolnshire fens. In passing, it may be mentioned that one of his brothers was the first of the Perry family who, for nearly a century, carried on the famous shipbuilding yard at Blackwall.

Perry was only one of many scores of foreigners who contributed to the furtherance of Peter's naval construction plans. Dutch, German, Swedish and Italian workmen and sailors were all to be found in the Russian yards and ships. One of the earliest establishments erected on the banks of the Neva at St. Petersburg was the Admiralty yard, from which in 1712, the Poltava, 50 guns, was launched. By 1715, upwards of 30 warships had left the slips,

all of them built of Kazan oak. At a later period, when the swamps and mud flats on which the city was founded had been piled, and embanked with granite walls, and wooden buildings had given place to others of stone, the Admiralty with its central spire dominated St. Petersburg like St. Paul's Cathedral does the City of London; but at first it was merely a large quadrangle, one side of which gave on the Neva. On the other sides were ten building slips, with wooden workshops. From 1711 the Admiralty was fortified. It was Peter's pride. At St. Petersburg was also the marine academy, originally founded in Moscow, and for which, in 1698, Peter had secured the services of the Aberdeen mathematician Farwharson or Farquharson. Subsequently, the academy was removed to the great naval base at Kronstadt, begun in 1710. It was here that the first steam engine in European Russia was set up, some 60 years later.

While ships and fleets appealed to Peter above all else, in his first visit to the West of Europe, when he worked as a shipwright at Saardam and Deptford, his inquiries ranged over many sciences, arts and industries. Nothing that could contribute to the modernisation and greatness of his Empire failed to secure his attention. He was then 26 years of age, and was a giant in stature and strength; domineering, cynical, fond of low society, and given to acting the buffoon, yet capable of turning aside to examine natural history collections, or visit observatories. He even took lessons in anatomy. He realised the value of science, endeavoured to enforce an acquaintance with mathematics on his young nobles, and had a respect for learning. One day in 1712, at Carlsbad, having talked of mathematics and science with Leibnitz, he asked, "What should he do now for his people?" and received the reply, "Build academies and universities in St. Petersburg, Moscow, Astrakhan and Kiev." This answer, and his meetings with scientific men in London, Paris and Germany, probably led to his plan for the inauguration of the Imperial Academy of Sciences at St. Petersburg, which came into existence in 1725, a few months after his death.

Two branches of industry that Peter fostered with fruitful results were mining and metallurgy, and many of the great enterprises about which so much is said to-day can be traced back to his reign. In the Sixteenth and early Seventeenth Centuries, Russia obtained her iron from Sweden. By 1631, however, an ironworks was in existence in the Urals; in 1632, a Dutch merchant, Vinius, was granted permission to start an ironworks in Tula; in 1670, iron was discovered in the Olonetz district; and here, eight years later, munitions—cannon and projectiles—were being manufactured at the Petrovsk works by von Rosenbusch, a native of Denmark. It is said that, by the end of the Seventeenth Century, there were some 20 small ironworks in Russia. Smelting was done in primitive bloomery furnaces, air being supplied by bellows driven by water wheels. Of fuel, there was abundance in the great Russian forests.

One of the steps taken by Peter to further the metal industry was to secure the services of capable mining engineers. Having done this, in 1701 he set up the first separate official mining administration. In 1719, he founded the Mining College for the management of mining affairs, and promulgated the first mining laws. These gave the right to prospect both on Government and private lands, even without the owner's consent. Rates for indemnification were fixed, and workmen in mines and metallurgical works were exempted from all taxation, and also from military service. In 1720 a decree was issued forbidding the improvement or the development of the mining industries, and authorising the importation of foreign workmen. In 1721, a mining school was opened at Ekaterinburg (now Sverdlovsk) in the Urals. The Higher Mining College in St. Petersburg was founded in 1773, in the reign of Catherine the Great.

With the extension of the industry in the reign of Peter, two men were intimately associated; one, a German mining engineer, who entered the Russian service at the same time as Perry, and the other a Crown serf working in an armoury at Tula. The former, Georg von Hennin, was born in Germany about 1676, and died in Russia in 1750; the latter was Nikita, the son of Demid Gregorievitch Antufejeu of Tula who died in 1690. Learning of Nikita's skill and intelligence, Peter sent him in 1699 to set up a foundry in the Urals and there Nikita built the Neviansk works, the first of a large group which laid the foundation of the wealth of a dynasty of mining kings, the Demidoffs, the name given by Peter to Nikita when he ennobled him. Nikita was followed by a son, Akinfi, and a grandson, Nikita. After them came Procope Demidoff, who died at the end of the Eighteenth Century; Nicholas Demidoff (1773-1828); Count Anatole Demidoff (1813-70), and others. Immensely rich, they used their wealth in founding academies and prizes, forming libraries and art collections, furthering exploration, and fostering the arts, sciences and literature. T. W. Atkinson, the architect and traveller, who visited Russia 90 years ago, in his *Oriental and Western Siberia*, wrote of the Ural properties of the family: "On this vast estate of the Demidoffs, containing 3,095,700 acres, nearly equalling Yorkshire, Nature has been most bountiful. Iron and copper appear to be inexhaustible. Platinum and gold are in the upper valleys, and malachite is found there also in enormous quantities, with porphyry and jasper of great beauty, and various coloured marbles. Their forests extend over more than 10,000 versts and are thickly covered with timber." There is a monument to the first Nikita Demidoff at Nijni Tagilsk, a city now having about 175,000 inhabitants.

The work of Georg von Hennin was more that of an organiser and a mining inspector than that of an industrialist. He modernised the plants, on which the army depended for munitions, opened up new mines, both iron and copper, built the Tula gun factory, was active in both the Olonetz and the Ural regions, and founded the fortified town of Ekaterinburg. He left in manuscript "A description of the Siberian metal works, both Government and private, with maps of all mining districts, etc." This manuscript passed from the Demidoff library to that of the Emperor Nicholas II, and when the Imperial collections were dispersed it went to America and is now in the New York Public Library.

Much pioneering work was done in the early part of the Eighteenth Century, not only in the Ural Mountains but also in the Altai (*i.e.*, Gold Mountains), a tract of the Asiatic continent eight times the size of Switzerland, which separates the plains of Western Siberia from the arid steppes of Central Asia. It is just north of the Altai that many modern industrial cities are found. If a line of latitude be drawn through Edinburgh and then continued eastward across the map of Europe and Asia, not far from it, either to the north or south, will be found Moscow, Nijni Novgorod (now Gorki) and Kazan, and the Siberian towns of Tobolsk, for long the capital of Western Siberia, and the birthplace of the great chemist Mendeleeff; Tomsk, where the superintendent of the Altai mines had his residence; Omsk, and Barnaoul, another old mining centre. The Altai metalliferous mines are still of importance, but of far greater value to-day is the great coalfield of Kuznetsk, lying to the south-east of Tomsk, where modern cities, like Stalinsk, are found.

Siberia was once inhabited by a people who, according to legend, were called Chud, *i.e.*, "wonder men." Their chief monuments are ancient mines. There are numerous remains of Chud mines in the Altai, and it was the discovery, in 1723, by Russian hunters, of some old workings that led Akinfi Demidoff, in 1726, to send thither miners from the Urals. The first mine opened, for silver smelting, was the Kolyvano Voskresensk works, near Lake Kolyvan in the Biisk region. In 1739, he opened the Barnaoulsky works. Other mines followed quickly and, in 1747, by an Imperial decree, all the mines in the Altai passed into the hands of His Majesty's Cabinet. In 1771, the Barnaoulsky works became the town of Barnaoul and this, in 1771, was made the administrative centre of a the works in the Altai region. Here, too, in 1779, was opened another mining school. It was to meet the needs of the local mining industry that, in 1771, an iron works was established at Tomsk.

The Barnaoulsky works have a special interest in Russian engineering industry, for it was here that the first atmospheric steam engine ever seen in Russia was built. Until recently the story of this engine has been but very imperfectly known, but about five years ago the original drawings and description were discovered and these have since formed the subject of an article in the *Proceedings* of the Leningrad Technical Institute for 1937. The article is in Russian, but a brief summary is given in English. The designer and constructor of the engine was the son of a Russian soldier and was named Ivan Ivanovitch Polzunow. He was born in 1728, served an apprenticeship as a mechanic at Ekaterinburg, and in 1747 was sent to the Altai mines and became an overseer. During the years 1763-66, at Barnaoul, he made first a model Newcomen engine, and then a full-size engine, and it is of interest to recall that his work was done at the exact time that Watt was experimenting with the Newcomen model at Glasgow University. Polzunow's model is still preserved at Barnaoul and in the article referred to are reproductions and drawings of the engine house, longitudinal and cross sections of the full-size engine, and sheets of details. The most interesting points about the engine are that it had two cylinders, instead of one, and that the pistons, working in opposite directions, drove two beams which were connected to machinery, and not to pumps. These features made the engine unique. Polzunow was entirely responsible for its design and construction. It was ready for trial in May, 1766; but, before it had been set in motion, Polzunow suddenly died. He was only 38 years of age. His death occurred on May 16; a week later the first trial took place, and in August the engine was used for industrial purposes. In November, the boiler gave out, through being neglected, and the engine was not used again. In his summary of Polzunow's work, M. Danilevsky says that "His remarkable achievements show that the creative genius does not depend upon either race or caste or any chosen category of men." There can be no doubt that his name should be included among those of the pioneers of steam power.

THE ROYAL SOCIETY OF ARTS.—The report on the examinations of the Royal Society of Arts for 1941 states that, over a long period, the entries have shown a steady annual increase only interrupted by serious crises, such as the war of 1914-18, the financial depression of 1932-34, and the present war. In 1939, the number of single-subject entries was 103,790. This fell to 57,000 in 1940, and a further drop to 50,030 occurred during the present year. The Society's educational adviser, Dr. F. H. Spencer, LL.B., states, however, that there appears to be little falling off in the quality of the work done and that this is a tribute both to the pupils and to their teachers who are working under difficult war-time conditions.

INSTITUTION OF CIVIL ENGINEERS.—After the consideration of the 18 entries received for the recent "Ingenuity Competition," the Council of the Institution of Civil Engineers has decided to divide the prize of 25 guineas between Mr. L. B. Escritt, A.M.Inst.C.E., for his paper, "The Sanitation of Tube Railway Stations Used for Air-Raid Shelters," and Mr. S. V. Gardner, A.M.Inst.C.E., for his paper, "Repair Work to Damaged Pumping Station." Owing to the success of the competition, the Council has decided to hold another on similar lines. The article should not exceed 2,000 words, and must describe a specific problem involving immediate action and ingenuity displayed in meeting it. The papers should reach the Institution by April 30, 1942, the MS. being marked "Ingenuity Competition" in the upper left-hand corner of the first page.

AUXILIARY WATER SUPPLIES FOR FIRE-FIGHTING.—The static-water tanks now generally provided for the A.F.S. are usually filled from the mains through steel pipes, of which a considerable weight may be required. In coastal towns, however, the sea provides an inexhaustible supply of water, though the total length of piping required may be longer than that from the mains, and, if of steel, not readily obtained. One seaside resort has got over the difficulty by using 9-in. bore asbestos-cement pipes, manufactured by Messrs. Turner's Asbestos Cement Company, Manchester, 17. The pipes have been laid from the beach to the cliff-top promenade, and then divide into two mains along the promenade, with branches to static-water tanks in various parts of the town. The pipes, being light, were easily transported and laid, and no difficulties from corrosion or incrustation are anticipated.

BRIQUETTING PRESS FOR METAL SWARF.

MESSRS. WILLIAM JOHNSON AND SONS (LEEDS), LIMITED, LEEDS.

Fig. 10.

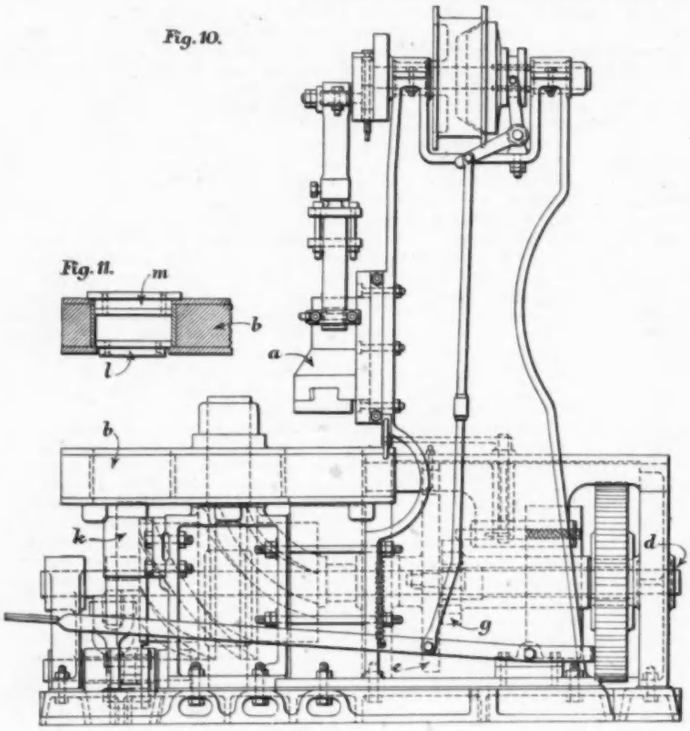


Fig. 11.

Fig. 12.

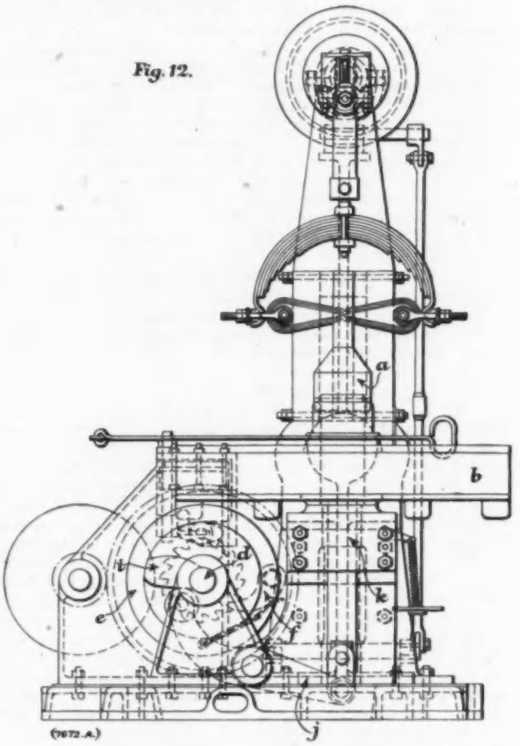
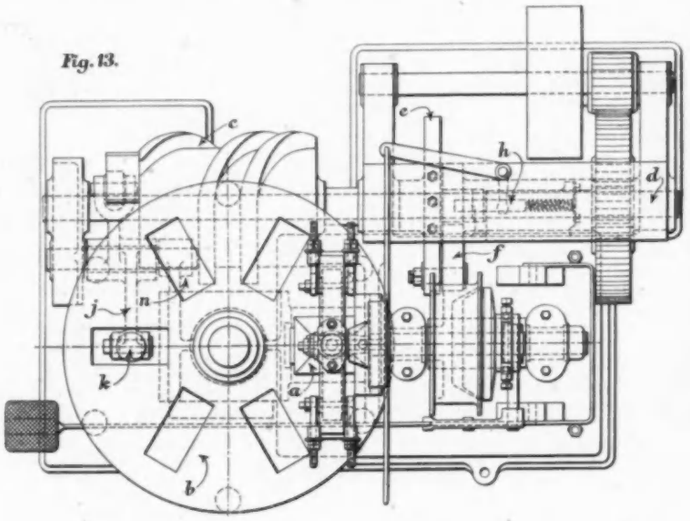


Fig. 13.



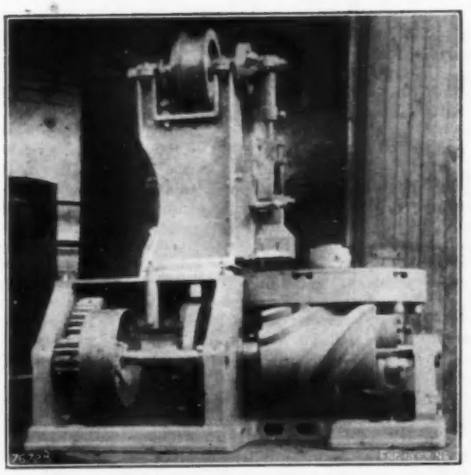


FIG. 14. BRIQUETTING MACHINE FOR STEEL SWARF.

BRIQUETTING PLANT FOR METAL SWARF.

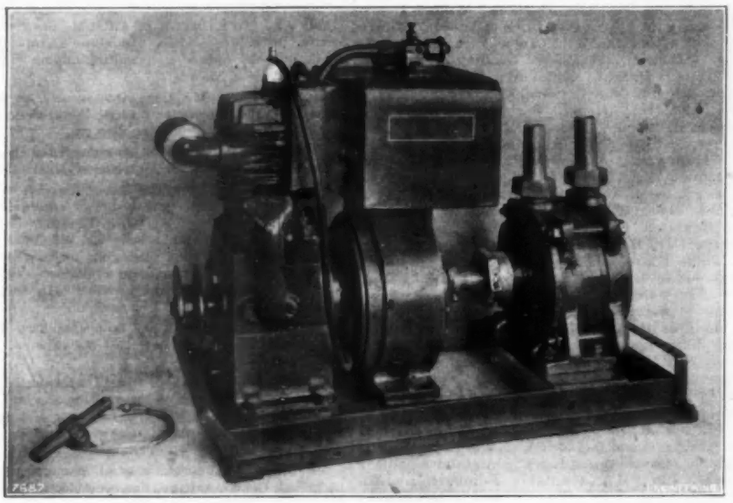
(*Concluded from page* 368.)

IT was pointed out in the first of our articles on swarf-briquetting plant, on page 306, *ante*, that the plant therein described was not suitable for handling steel swarf. It will be realised that the long helical swarf resulting from heavy turning or facing cuts or from fluted drills of large diameter working on steel do not lend themselves to briquetting as readily as do the indeterminate chips of cast iron and many of the non-ferrous metals and alloys, even when this long swarf is broken into smaller pieces by a chip-breaking attachment on the cutting tool. Some firms feed the steel swarf into a cupola or remelting furnace in a loose condition as it comes from the machine; others, again, employ a baling press, either hand-operated or power-operated. Baling presses, however, are only suitable for irregular bulky scrap, such as that resulting from stamping operations, and when they are employed for swarf the resulting bundles are much less dense than briquettes. When fed loose into a furnace the swarf may, with advantage be reduced to pieces 3 in. long in some form of crushing machine. No data regarding the melting losses incurred by disposing of steel swarf in this way are available, so that the advantages of briquetting it cannot be accurately assessed, but if the reduction in melting losses between loose swarf and briquetted swarf is as marked in the case of steel as it is in cast-iron, there can be no doubt that briquetting is an economical process; it is obviously economical from the point of view of transport.

To show whether decreased melting losses result from the briquetting of steel swarf it is necessary to provide means for producing briquettes of this material of the same order of density as those of cast iron, viz., 70 per cent. to 75 per cent. of that of the solid metal. Messrs. W. Johnson and Sons (Leeds), Limited, have recently paid considerable attention to the subject of steel swarf briquetting and one of the firm's latest machines, which has proved very satisfactory, is shown in Figs. 10 to 14, on this page. This is a tamping press with a revolving table, the swarf being compacted by a tamping hammer delivering 250 blows per minute. The swarf, reduced to pieces about 3 in. long, is passed through a rotary furnace in which it is brought to a red heat, being placed in this condition in the mould. The hammer *a* is reciprocated by a crank on the driving shaft, the crankpin being adjustable on the crank disc so that the stroke may be varied. This construction will be clear from Fig. 10, in which it will be also noticed the crankshaft is driven by a belt pulley, engagement and disengagement being effected by a cone clutch actuated by a pedal. The blow is not of the "dead" type, but, owing to the bow spring inserted between the crankpin and the tup, has the

PORTABLE PETROL-DRIVEN PUMP.

MESSRS. BRADBY'S ENGINEERING WORKS, LIMITED, DITCHLING, SUSSEX.



resilience necessary for compacting the swarf. The connecting rod is telescopic in order to enable the distance between the face of the tup and the crankpin to be varied. The hammer is guided in slides.

The table *b* rotates round a fixed pin, and, as shown in Fig. 13, has six rectangular perforations arranged radially. These perforations form the moulds in which the swarf is compacted. A section through one of them is shown in Fig. 11, from which view it will be seen that they are lined, the lining plates being of abrasion-resisting steel. The body of the table is of cast iron faced with steel plates top and bottom. Six pins situated near the periphery and spaced centrally between the moulds project from the bottom and engage with helical channels on a cylindrical cam *c*. This engagement is visible in the external view of the press shown in Fig. 14, and from both this view and from Fig. 13 it will be understood that the channels are at right angle to the axis of the cam for part of their path, so that there are pauses in the rotation of the table when the cam is being rotated. The pitch of the channels is such that the pins on the table successively engage with them. The cam runs freely on the shaft *d*, which is driven through spur reducing gear by a belt pulley; it can be coupled to and uncoupled from the shaft at will. The cam is attached to a disc *e*, which carries a pawl *f*. The driven shaft *d* has a ratchet wheel *g* keyed to it, and so long as this wheel and the pawl are engaged, as shown in Fig. 12, the cam rotates with the shaft, the pawl being held in position by the leaf spring shown on the disc *e*. Disengagement of the cam and shaft is effected by the spring-loaded pin *h*. This pin, as will be gathered from Fig. 13, normally projects into the path of the pawl and lifts this clear of the ratchet wheel against the pressure of the leaf spring, so that the cam movement ceases. The position of the pin is controlled by the pull-road and lever system seen in both Fig. 13 and Fig. 14. On withdrawal of the pin by the pull rod, the pawl engages and the cam rotates so as to turn the table through an arc of 60 deg., and thus move it round from one mould position to another.

The spring on the pin, in the meantime, projects the pin in way of the pawl, with the result that the table stops automatically after each one-sixth of a revolution, the shaft *d* continuing to revolve. The shaft carries a cam *i*, which engages with a roller on one arm of the lever system *j*. The other arm is coupled by a link to a vertical ejecting rod *k*, situated on the table centre line, opposite to the hammer, as shown in Fig. 13. The ejecting rod moves upwards at every successive station of the moulds. The end of the rod does not come directly into contact with the briquette, but bears on a false bottom *l*, shown in the mould in Fig. 11. From this view it will also be noted that a loose top *m*, fitting into the mould, bears directly on top of the swarf to be compressed. It is this top which is struck by the tup. The filling station is the next to the ejecting station and is indicated at *n* in Fig. 13. Three operations are carried out simultaneously at every pause in the table rotation, viz., filling the mould, tamping the swarf in a filled mould, and ejecting a completed briquette. The capacity of the machine with a crankshaft rotation of 250 r.p.m. is from 120 briquettes to 240 briquettes per hour. The various parts of the machine are assembled on a common bedplate, so that, with the exception of the power source, it is self-contained. The pulleys operating the crankshaft and the cam-driving shaft can be driven from the same countershaft, about 5 h.p. being required for the production stated above.

The present-day outlook on swarf briquetting may be thus summarised: loose swarf, regarded in the past as a by-product to be disposed of at some cost and trouble, is a useful material when briquetted. Whether or not the briquetting of swarf is profitable depends upon the quantity produced. The present-day selling price of cast-iron swarf may be taken as 10*s.* per ton, approximately, though we understand that sales may sometimes be effected to certain chemical works at 25*s.* per ton. Taking the lower figure, however, and the cost of briquetting at 7*s.* 6*d.* per ton (see also page 306, *ante*) the cost of briquettes comes to 17*s.* 6*d.* per ton. Since, however, cast-iron briquettes may be used in the foundry instead of scrap costing 4*l.* per ton, there should normally be a balance in favour of briquetting sufficient to pay off the capital cost of the plant in a short time. Moreover, since some firms have found that cast-iron briquettes are equal in metallurgical value to some special alloys costing 7*l.* per ton, there are possibilities of even greater profit from their use.

PORTABLE PETROL-ENGINE DRIVEN PUMPING SET.

THE compact portable pumping set illustrated by the photograph reproduced on this page is operated by a petrol engine of the same size as is used in the 300-watt portable electric generating set described in ENGINEERING, vol. 150, page 16 (1940), both sets being manufactured by Messrs. Bradby's Engineering Works, Limited, Ditchling, Sussex. The set, it will be clear, is mounted on a light angle iron base with a carrying handle at each end and is thus readily transportable and so adapted for emergency use. The pump, which is of the self-priming centrifugal type, is capable of delivering 450 gallons per hour with a suction lift of 25 ft. and a discharge head of 30 ft. The suction and delivery pipes are 1 in. in diameter and are arranged one on the cover and one on the pump body, the pump cover being held in place by four bolts in order to provide ready access to the interior of the pump. The pump is directly coupled to the engine, the impeller spindle passing through a screwed stuffing box. The attachment to the engine crankshaft is made by a flexible coupling.

The engine is of the four-stroke cycle type with a single cylinder of 2 in. bore by 2 in. stroke developing 1½ h.p. It is capable of running at a speed of 2,500 r.p.m., as when driving a generating set, but for pumping it is set to run at from 1,500 r.p.m. to 1,700 r.p.m. The cylinder is air-cooled, the air being circulated by a fan on the flywheel discharging through a cowl. The valve springs and stems are cooled by discharge from the crankcase breather which is splayed as shown. The crankcase is of aluminium and the cylinder head and piston are of light alloy. The connecting rod is of gunmetal. The crankshaft is mounted in ball bearings and splash lubrication from the crankpit is provided. The carburettor is of suction type with adjustable choke and throttle. Ignition is by means of a Wico flywheel magneto, with an advance and retard lever. Any 14 mm. sparking plug can be fitted. Starting is effected by a pull-rope of wire. The normal fuel is ordinary Pool petrol, the consumption being 0·67 pint per hour. A 0·5 gallon fuel tank is arranged above the flywheel. Alternatively, the engine will run satisfactorily on paraffin, if two or three injections of petrol are made through the choke hole to warm up on starting. If the set is intended to run on paraffin, the carburettor can be adjusted for this fuel before the engine leaves the works.

IRRIGATION IN INDIA.*

By SIR BERNARD DARLEY, M.Inst.C.E.

THE Government has spent over 100,000,000*l.* on canals throughout India. These irrigate some 30 million acres and the value of the crops raised by the help of this water is estimated at nearly 70,000,000*l.* annually. The canals, as a whole, pay about 5 per cent. on the capital outlay after meeting expenses. The important factor is that they have banished famine and brought prosperity and contentment to the cultivator.

Only a few works of any magnitude were constructed before the country came under British rule. Probably the oldest of these was the Cauvery Delta system of canals, which were supplied from an ancient stone weir built some 1,700 years ago. The first efforts of the British engineers under the East India Company were directed towards the improvement of old indigenous work. The Western and Eastern Jumna Canals were reopened in 1821 and 1830, respectively, and the old masonry weir across the Cauvery in Madras was replaced by a new weir with sluices, and the remodelled canals were opened in 1838.

The terrible famines which ravaged the country led to the rapid expansion of irrigation works, both by the East India Company, and, later, by the Government of India. During the Orissa famine of 1866-67, over a million people died, or about a quarter of the population. Gradually, the waters of every river in northern India were harnessed and more and more land protected, until, by 1920, only a few large schemes about which there had been considerable controversy remained. In Central and Southern India, huge storage dams were constructed which held up the monsoon rainfall for use during the dry months of the year.

After the last Great War, three huge canal projects were sanctioned. These were the Sukkur Barrage Canals in Sind, the Sutlej Valley Canals in the Punjab and Bahawalpur and Bikaner States, and the Sarda Canal in the United Provinces. The Sarda Canal takes water from the Sarda river on the borders of Nepal, in the north of the United Provinces. It commands some seven million acres in Oudh and Rohilkand, has 4,177 miles of main canal distributaries, and is the longest canal in the world. In addition, some 1,500 miles of drainage channels were constructed to carry off rainwater quickly. The cost of this scheme was 7,500,000*l.* The headworks are situated in the heart of one of the most fever-stricken forests in India, where the average monsoon rainfall is over 100 in. each year. All labour had to be imported. The first task was to clear some 400 acres of dense forest at the headworks to enable workshops, labour camps and store sheds to be built. It was also necessary to cut a wide belt some 60 miles long through similar forest for the main canal and one of the main branches. The work was completed in 1928.

The country to be irrigated by the Sind and Punjab canals was very different to that in the Sarda canal. Apart from riverain tracts already irrigated during the flood season, the country was waterless desert. The rainfall is only 3 in. to 5 in. a year, and spring level is generally 100 ft. or more below the surface. Colonisation of the desert areas where land was good offered few difficulties. All unclaimed land was taken over as Crown waste; some was auctioned in large blocks, but for the most part it was sold to peasant proprietors, who poured in from the overcrowded districts farther north. No peasant proprietor is allowed to purchase more than 50 acres in all, and they pay by instalments as they earn money from the land. The area is divided into villages and men of the same community are given land together. Each village is given one or more watercourses and the cultivators generally arrange

* Paper read at a meeting of the India and Burma Section of the Royal Society of Arts, in conjunction with the East India Association, on Friday November 14, 1941. Abridged.

among themselves to divide the water fairly, each man taking all the water in his turn. If necessary, however, a canal officer fixes the turns when the people cannot agree among themselves.

The Lloyd Barrage at Sukkur is the largest work of this kind in the world. It consists of 66 spans of 60 ft. each, which can be closed by steel gates and the water headed up and passed into canals, of which there are seven in all. They have a total length of 6,400 miles and can draw off a combined discharge of 46,000 cusecs. These canals command a gross area of 7½ million acres, of which 5½ million acres will eventually be irrigated. Some 3¾ million acres were desert land, while the remainder received water in the past during the flood season from old inundation canals. The total cost of this great scheme to date has been over 21,000,000*l.*, excluding interest charges.

A scheme of almost greater magnitude is the Sutlej Valley Project, in the Punjab. This scheme was designed to utilise the surplus water in the Beas river below its junction with the Sutlej. There are in all ten canals taking off above four barrages (one of which is second only to the Sukkur Barrage in order of magnitude) with a total length of 9,600 miles. These draw a combined discharge of 48,516 cusecs. It was anticipated that 5 million acres would be irrigated by these canals, of which 2 million acres of desert land would be colonised and brought under cultivation. The total cost of this great scheme has been over 16,000,000*l.*

The fourth great work undertaken during the past 20 years is the Mettur Dam, on the Cauvery River in the Madras Presidency. It is by far the most massive dam in the British Empire and is second only to one other dam in the world. It comprises more than twice the volume of masonry and concrete contained in the Assuan dam on the Nile, being nearly a mile long and 214 ft. high. The reservoir above it covers an area of 59 square miles, and holds 93,500 million cub. ft. of water. The water so stored is used to supplement the supplies of the old Cauvery canals and also to irrigate a new area of 301,000 acres. This great scheme has cost some 5,000,000*l.*

The last big project to be completed in India is the Haveli Canal, taking off from the Chenab river in the Punjab. The canals are expected to irrigate 888,000 acres annually, of which 550,000 acres received a precarious supply in the past from old inundation canals. One large canal remains to be completed in Northern India, namely, the Thal Canal. This will take off from the Indus river, and will irrigate a dry, sandy tract, badly in need of water. With the completion of this project the waters of all rivers in Northern India will have been utilised as far as is economically possible.

It will be necessary to turn to new methods for any future development. The first that suggests itself is the tapping of the vast reservoirs of subsoil water by means of tube wells. A scheme of this nature was first undertaken some years ago near Amritza, in the Punjab. A similar project, but on a much more extensive scale, has been undertaken of late years in the United Provinces, where a scheme costing over 2,500,000*l.* is nearing completion. Several falls on the Upper Ganges canal have been harnessed and the electrical power developed is utilised both for light and industrial purposes in 88 towns in the northern portions of the Provinces, and also for pumping water from Government and private tube wells. Some 1,500 tube wells have been sunk by the Government. Thus, nearly 600,000 acres are irrigated annually in areas which cannot be given canal irrigation.

A scheme of some magnitude has also been undertaken in the United Provinces to pump water from the Gogra river, which lies too low to permit of flow irrigation in the ordinary manner. Another possible form of development is the further construction of storage dams to hold up monsoon rainfall. It is unfortunate that the rock of which the Himalayas are formed is so fissured that very few sites exist where high storage cams can be built.

One notable work has been projected in the Punjab. There a suitable site exists on the Sutlej river and various schemes have been prepared for a dam, which is known as the Bakra Dam. Proposals for this dam varying from one 400 ft. to one 500 ft. high have been made, with reservoirs above holding 80,000 to 120,000 million cub. ft. of water. Lastly, there is the question of making existing supplies go farther. Only about 50 per cent. of the water entering a large canal reaches the fields; the remainder is absorbed into the ground on the way or lost by evaporation. Experiments are being made with various materials for lining canals, to see if any cheap and efficient method can be devised to check this leakage.

BEACH TIN OPERATING COMPANY (GWYTHIAN) LIMITED.—We are informed that Messrs. George Cohen, Sons and Company, Limited, have acquired the whole of the machinery and plant of Messrs. Beach Tin Operating Company (Gwythian), Limited, near Hayle, Cornwall.

INSTITUTION ELECTIONS.

INSTITUTION OF CIVIL ENGINEERS.

Student to Associate Member.—Peter Lawrie Aitken, B.Sc. (St. Andrews), Dundee; Guy Dunn Allison, B.Sc. (Durham), Parkstone, Dorset; John Edward Henry Anderson, Balmedie, Aberdeen; William Henry Appleyard, B.Sc. (Eng.) (Lond.), Manchester; Gilbert John Barrington, Stafford; John Michael Birdsell, M.Eng. (Sheffield), Sheffield; Geoffrey Boardman, B.Sc. (Eng.) (Lond.), Guildford; Merville Harry Britten, Shepton Mallet, Somerset; Frank Edward Bruce, M.Sc. (Eng.) (Lond.), Surbiton, Surrey; Ross Campbell, Evesham; Norman Dobson Carter, B.Eng. (Liverpool), Little Hougham Court, near Dover; James Leith Clark, Aberdeen; Cyril Austen Collins, Bridlington; Basil Glover Combridge, Kingston-on-Thames; Joseph Cowan, Gloucester; Ian Gordon Croxford, B.Sc. (Eng.) (Lond.), Portland, Dorset; Cyril Hewetson Davison, Rickmansworth; Harold Stanhope Day, B.Eng. (Liverpool), Dewsbury; Kenneth John Evans, B.Sc. (Eng.) (Lond.), Swansea; Robert James Evans, B.Sc. Tech. (Manch.), Eccles, Lancs; Hugh Duncan Findlay, B.Sc. (Glas.), Glasgow; William Stewart Forbes, B.Sc. (Edin.), Edinburgh; William Lees Foster, B.Sc. (St. Andrews), Dundee; Alfred John Louis Gamper, B.Sc. (Eng.) (Lond.), London, S.W.18; James Nicholson Garden, Harrow, Middlesex; James Clifford Garnett, London, W.2; Ivan Sydney Stroulger Greeves, Surbiton, Surrey; Ernest Reginald Griffiths, Coventry; Gilbert Claude Harvell, Boston; Frederick Denis Cameron Henry, B.Sc. (Eng.) (Lond.), London, N.3; John Robert Houghton, Cleethorpes, Lincs; Alexander Milroy Kennedy, Jun., B.A. (Cantab.), Edinburgh; John Charles Landon, B.Sc. (Eng.) (Lond.), Devonport; Ernest Wilson Latham, B.Sc. (Eng.) (Lond.), Haywards Heath, Sussex; Kenneth Campbell McCrae, Singapore; Archibald McDougall, B.Sc. (Edin.), Scone, Perth; Robert Stuart McNeill, Sao Paulo, Brazil; Albert Desmond Hutchinson Martin, B.A.I. (Dublin), Morecambe; Gilbert Frank Norris, Derby; Elrington Robert Lennard O'Toole, B.Sc. (Eng.) (Lond.), Singapore; Basil Harold Pattinson, B.Sc. (Eng.) (Lond.), Wembley, Middlesex; Walter George Prow, Elgin, Moray; Arnold John Richmond, B.Sc. (S. Africa), Durban, Natal; Cyril Rigby, Buxton; Frederick Louis Robinson, B.Sc. (Eng.) (Lond.), Leeds; Frederick Raymond Salkeld, Lincoln; Arthur Shallcross, Peterborough; Jack Bromley Stapley, Boston; John Stewardson, Carlisle; Alastair Storrar, B.Sc. (Edin.), London, S.W.1; Nilkanth Ramchandra Tembe, M.Sc. (Eng.) (Lond.), B.E. (Bombay), London, W.1; John Thompson, Fishguard; John Leslie Timbers, Ilford; John Leslie Unitt, Camberley, Surrey; John Francis Varcoe, B.Sc. (B'ham.), Newport, Mon.; Edward Charles Vaughan, Abergavenny; John Philip Wain, Birmingham; Ronald Leslie Walshe, B.Sc. (Belfast), Belfast; John Edmund Gifford Whittome, March, Cambs.; Geoffrey Wimpenny, B.Sc. (Leeds), Derby; Stanley Whyte Wood, B.Sc. (Aberdeen), Surbiton, Surrey.

BOOKS RECEIVED.

United States Bureau of Labor Statistics. Serial No. R. 1325. *Earnings in the Seamless-Hosiery Industry Under 32½-Cents Minimum Wage.* By FRANCES JONES and G. E. VOTAVA. Washington: Superintendent of Documents.

The Railways of Persia. A Description of the Trans-Persian and Other Lines, Completed, Building or Projected, and of the Railway from Quetta to Duadap. London: "The Railway Gazette," 33, Tothill-street, Westminster, S.W.1. [Price 2*s.*]

Understanding Aero Engines, by Question and Answer. By W. HAZELL. St. Hugh's School, Bickley, Kent: The English Universities Press, Limited. [Price 2*s.* 6*d.* net.]

Economic Peace Aims. A Basis for Discussion. By OSWALD DUTCH. London: Edward Arnold and Company. [Price 12*s.* 6*d.* net.]

Cofferdams. By LAZARUS WHITE and E. A. PRENTIS. New York: Columbia University Press. London: Oxford University Press (Sir Humphrey Milford). [Price 50*s.* net.]

Society of Chemical Industry. Chemical Engineering Group. Proceedings. Volume 22. 1940. London: Chemical Engineering Group, 56, Victoria-street, Westminster, S.W.1.

The Journal of the Iron and Steel Institute. Volume XCLIII. 1941. No. 1. Editor: K. HEADLAM-MORLEY, Secretary. Assistant Editor: A. E. CHATTIN, Assistant Secretary. London: Offices of the Institute, 4, Grosvenor-gardens, Westminster, S.W.1.

Post-War Questions. No. 9. *Beware Bureaucracy!* By LORD PERRY. London: The Individualist Bookshop, Limited, 154, Fleet-street, E.C.4. [Price 6*d.*]

PERSONAL.

MR. W. A. GALLON, B.Sc., M.I.E.E., deputy borough electrical engineer, Corporation Electricity Department, Southampton, has been appointed borough electrical engineer, Woolwich Borough Council Electric Supply, London, S.E.18.

MR. W. J. D. KLOEZEMAN, A.I.M.M., has resigned his position with Messrs. Kay Tin Mines (Kinta) Limited, Perak, and has opened a consulting mining engineering practice at Ipoh, Malaya.

MR. C. D. TAITE, M.I.E.E., director, chief engineer and manager to the Lancashire Electric Power Company, has now been appointed managing director.

MR. T. H. HEWLETT, M.P., has succeeded the late SIR ROBERT WADDINGTON as Controller of Dyestuffs.

MR. GEORGE WOOD has been released from the Directorate of Scrap as the result of an urgent request made by Messrs. Thos. W. Ward, Limited, Sheffield, to the Controller of Iron and Steel. Mr. Wood has returned to his position as joint managing director of Messrs. Ward but has agreed to remain available to the Control for consultation from time to time. His successor as Director of Scrap is MR. F. S. TOWLE.

MR. BERNARD THOMAS has been appointed managing director of Messrs. Midland Heat Treatments, Limited, Wolverhampton.

DR. J. L. MILLER, M.I.E.E., M.Amer.I.E.E., by arrangement, has resigned his position as chief research engineer to Messrs. Ferranti, Limited, and is joining Messrs. British Insulated Cables, Limited, Prescot, Lancashire, as deputy chief engineer.

MR. A. E. SYLVESTER, general manager of the Gas Light and Coke Company, has been elected chairman of the London Regional Gas Centre.

MESSRS. THE ACCURATE RECORDING INSTRUMENT COMPANY have opened a London office at Windsor House, 46, Victoria Street, S.W.1. (Telephone ABBey 6758.)

MESSRS. W. T. HENLEY'S TELEGRAPH WORKS COMPANY, LIMITED, inform us that their advertising department has moved to new offices at 10, Market Square, Westerham, Kent.

MR. ANDREW HOPPER, for the past five years commercial manager to Messrs. The Parsons Marine Steam Turbine Company, Limited, Turbinia Works, Wallsend-on-Tyne, has now been appointed a director of the Company.

MR. A. F. SIDGREAVES, O.B.E., has been elected President of the Society of British Aircraft Constructors, Limited, 32, Savile-row, London, W.1, in succession to SIR FRANK SPRIGGS who has been President since July, 1939. SIR CHARLES BRUCE-GARDNER, M.I.Mech.E., is the permanent executive chairman of the Society. MR. J. D. NORTH has been elected vice-president (aircraft), in succession to MR. F. HANDLEY PAGE, and MR. C. C. WALKER, vice-president (engines), in succession to MR. H. J. THOMAS. MR. R. H. DOBSON has been re-elected honorary treasurer of the Society.

The title of Professor of Mining Geology in the University of London has been conferred upon DR. W. R. JONES, D.Sc. (Lond.), M.I.M.M., F.G.S., in respect of the post held by him at the Imperial College of Science and Technology.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Activity throughout the local staple trades has been well maintained. Some sections have increased outputs, particularly the tool and lighter industries, where the introduction of female labour has been of great help. There is a strong call for basic steels of all types, and business is also brisk in acid steel. The scrap market is strong, and a growing tonnage of scrap is becoming available. Orders are more numerous for all types of steelworks' and ironworks' plant. Electrical equipment is a progressive line. Large quantities of high-efficiency steels are leaving this district for areas concentrating on the production of generators, transformers, switchgear, and other types of electrical plant. Sheffield works are turning out large hollow forgings and boiler drums in connection with electrical developments in various parts of the country, and high-pressure vessels are also on order for other purposes. A steady trade is being done in mining plant; larger quantities of steel arches and girders are being supplied for use in the pits. Coal-cutting machinery is also in demand.

South Yorkshire Coal Trade.—Overseas trade shows little change, but the inland position is stronger. Industrial coal is in good demand, and iron and steel works are consuming larger tonnages. There is a good market for steam coals, and smalls and slacks are being supplied in large quantities to power stations and gas works. A seasonal trade is being done in house coal. The coke market has become more brisk; foundry and furnace sorts are steady, and there is a good demand for blast-furnace coke.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Welsh Coal Trade.—A sub-committee of the Conciliation Board for the South Wales coalfield has under consideration the question of reclassifying the wage groups. This position has arisen as a result of the fact that the four-year conciliation board agreement reached in 1937 can now be terminated. Under that agreement the respective bases of payment for a large variety of occupations in the industry were reduced to four grades for day wage earners and one for piece workers. Each of the four grades covers a large number of specific occupations which formerly had a special wage rate. Some of the workmen have complained that they had not been fairly graded and the Conciliation Board is reviewing the position in all its aspects. Buyers still experienced difficulty in covering their requirements for early delivery on the steam-coal market during the past week. There was a keen demand from home consumers, but collieries had sufficient orders on hand to provide a steady outlet for almost the whole of their potential outputs, and stems were difficult to arrange for some time to come. There was a good demand in some of the foreign trades, but export business continued to be checked by the official restrictions designed to retain as much coal as possible for the home industries. What coal was being shipped was usually of the low-volatile descriptions. Best large coals were still being steadily lifted and were very firm. There was a good demand for the sized classes, particularly for the dry steam sorts, which were only sparingly offered and were consequently firm. The bituminous small sorts were the strongest feature of the market and were still scarce. Dry steam smalls, on the other hand, were in little demand and were usually readily available and dull. Cokes were brisk and firm, while patent fuel was quietly steady.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—Activity in the Scottish steel trade continues at a high level. Steel plates are in strong demand, largely for the shipbuilding industry, but also for boilermakers, who are extremely busy. Special high-grade steel is receiving considerable attention, and the demand for deliveries for use in Government contracts is increasing. Makers of black-steel sheets are well placed for business, and structural sections are in fairly good demand. Home requirements are absorbing the bulk of the present production, but some good inquiries have recently been received from overseas, although there is practically nothing available for export. Supplies of raw materials are ample for current requirements. The following are to-day's quotations :—Boiler plates, 17*l.* 12*s.* 6*d.* per ton ; ship plates, 16*l.* 3*s.* per ton ; sections, 15*l.* 8*s.* per ton ; medium plates, ¼ in. and thicker, rolled in sheet mills, 21*l.* 15*s.* per ton ; black steel sheets, No. 24 gauge, 22*l.* 15*s.* per ton ; and galvanised corrugated sheets, No. 24 gauge, 26*l.* 2*s.* 6*d.* per ton, all for home delivery.

Malleable-Iron Trade.—Conditions in the West of Scotland malleable-iron trade show little change. There has been a good demand for rivet, bolt and nut bars, but the total output is not as heavy as it might be. Supplies of wrought-iron scrap are not very plentiful. The re-rollers of steel bars have a good deal of work on hand, and although their production is considerable more business could be dealt with. Ample stocks of semies are now in hand. The current quotations are as follow :—Crown bars, 15*l.* 12*s.* 6*d.* per ton ; No. 3 bars, 13*l.* 12*s.* 6*d.* per ton ; No. 4 bars, 13*l.* 17*s.* 6*d.* per ton ; and re-rolled steel bars, 17*l.* 15*s.* per ton, all for home delivery.

Scottish Pig-Iron Trade.—The strong demand for Scottish pig-iron continues and the total output is quickly taken up. Hematite iron is strictly controlled, but basic iron is more easily obtained, and there is a good trade in foundry grades. Adequate stocks of raw materials are now held. The following are the present market quotations :—Hematite, 6*l.* 18*s.* 6*d.* per ton, and basic iron, 6*l.* 0*s.* 6*d.* per ton, both delivered at the steel works ; foundry iron, No. 1, 6*l.* 5*s.* 6*d.* per ton, and No. 3, 6*l.* 3*s.* per ton, both on trucks at makers' yards.

BEARINGS FOR ALUMINIUM ROLLING MILL.—Messrs. Timken Roller Bearing Company have recently supplied four tapered-roller bearings for the backing-up rolls of a new four-high reversing hot rolling mill at the Alcoa Works, Tennessee, of the Aluminium Company of America. Each bearing has a diameter of 51 in., a bore of 35½ in., a width of 36 in., and weighs over 4 tons. Each bearing consists of a four-cage assembly containing 34 machined, case-carburised rollers. There are thus 136 rollers per bearing and each individual roller has a length of 7¼ in., a mean diameter of 4 in., and a weight of 23·37 lb.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—Conditions still practically preclude the transaction of general commercial business, but the supply of nearly all descriptions of iron and steel is sufficient for requirements of national importance. Raw materials and most semi-finished products are plentiful, and local and other native ironstones are being used extensively in place of foreign ores.

Cleveland Iron Trade.—The scarcity of Cleveland pig is of little importance as ample quantities of foundry iron are obtainable from the Midlands and other producing areas. Delivery licences are issued freely and consumers have taken the opportunity of securing themselves against any temporary shortage. Most foundries have a fair amount of work in hand and are using slightly larger quantities of pig, notwithstanding the extensive consumption of scrap. Transactions through merchants showed a slight further increase. The stabilised quotations of Cleveland pig remain at the level of No. 3 quality at 128*s.* delivered to local buyers.

Basic Iron.—There is no shortage of basic iron, but makers are retaining the whole of the output for the requirements of their own steelworks and, with no tonnage on the market, the fixed price of 120*s.* 6*d.* is nominal.

Hematite.—Some restrictions in the distribution of hematite are still unavoidable to provide adequate deliveries for essential purposes, but conditions are improving as makers and consumers adapt themselves to the changed conditions. Refined iron is being used in place of hematite in increasing quantities. The recognised market values of the latter are ruled by No. 1 grade of iron at 138*s.* 6*d.* delivered to North of England customers

Blast-Furnace Coke.—There are few transactions in Durham blast-furnace coke. The official prices are firm on the basis of 36*s.* 9*d.* f.o.r.

Manufactured Iron and Steel.—The tonnage of semi-finished iron and steel stored at the re-rolling mills has been drawn upon to some extent recently, but the delivery of home products has increased and the aggregate stock remains at a satisfactory level. Manufactured iron producers making light commodities could handle more work, but other departments are well employed. The demand for special alloys is straining the sources of supply, but shipbuilding requirements are being met satisfactorily and the distribution of sheets is adequate.

Scrap.—Consumers of heavy iron and steel scrap are keen buyers, but users of the lighter varieties have covered their requirements as extensively as they consider necessary.

WAR-RISK INSURANCE OF COMMODITIES.—The Board of Trade, with the approval of the Treasury, has decided that, in respect of the period beginning December 3, 1941, and ending March 2, 1942, the rate of premium payable under any policy of insurance issued under the Commodity Insurance Scheme, War Risks Insurance Act, 1939—Part II, shall continue to be at the rate of 7*s.* 6*d.* per cent. per month.

RETURN OF BUILDING AND CIVIL ENGINEERING LABOUR.—With reference to our note on page 393, *ante*, regarding the return, called for by the Minister of Works and Buildings, from the firms who employ some building and civil engineering labour on maintenance and similar private work, but who are not themselves registered building or civil-engineering contractors, we now learn that the closing date for the return of completed forms (No. B.C.E. 4) has been postponed until December 2. The original closing date, it will be remembered, was November 22. If any employer is in doubt as to whether he is liable to make a return, he is advised to go to the nearest Employment Exchange and ask for a form No. B.C.E. 4.

THE CONTROL OF EXPORTS.—Under the Export of Goods (Control) (No. 38) Order (S.R. & O. 1941, No. 1713, price 1*d.*), export control is extended to cover a wide range of metal manufactures, synthetic resins and other goods. In future, licences will be required to export cellulose acetate moulding powders ; synthetic resins of the formaldehyde condensation type ; steel shot and grit ; steel rules and measuring tapes ; bells and bell gongs ; metal ladders ; welding electrodes ; metal wheelbarrows ; parts of rail locomotives and vehicles ; points, switches, crossings, chairs, tie bars and rail brakes ; wheels, tyres, hubs, axles and brakes, wholly or mainly of metal, of the type used on animal-drawn vehicles and hand trucks ; and lightning conductors. The control relating to certain specified parts (engines and chassis, etc.), of mechanically-propelled road vehicles has been extended to cover all parts and accessories—wholly or mainly of metal—of such vehicles. Sulphuric acid, including oleum, the exportation of which was previously prohibited to all destinations, will now require licences for certain specified destinations only.

NOTICES OF MEETINGS.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

INSTITUTION OF MECHANICAL ENGINEERS.—To-night, 5.30 p.m., Storey's-gate, St. James's Park, Westminster, S.W.1. Informal Meeting. Discussion on "Practical Vibration Problems," to be introduced by Dr. H. L. Guy.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—To-night, 6 p.m., The Rooms of the Literary and Philosophical Society, Newcastle-upon-Tyne. "Further Experiments with Models of Cargo-Carrying Coasters," by Dr. F. H. Todd and Mr. J. Weedon. *Student Section :* Wednesday, December 3, 6.45 p.m., Bolbec Hall, Newcastle-upon-Tyne, 1. A series of short technical films.

KEIGHLEY ASSOCIATION OF ENGINEERS.—To-night, 7 p.m., The Victoria Hotel, Keighley. "Impact and Notched-Bar Testing," by Mr. C. N. Waterhouse.

INSTITUTION OF PRODUCTION ENGINEERS.—*Manchester Section :* Saturday, November 29, 2.15 p.m., The College of Technology, Manchester. "Surface Finish," by Dr. G. Schlesinger.

JUNIOR INSTITUTION OF ENGINEERS.—Saturday, November 29, 2.30 p.m., 39, Victoria-street, Westminster, S.W.1. Ordinary Meeting. "The Engineer and the Rest of the World : A Study in Relationships," by Mr. K. S. Jewson.

INSTITUTION OF ELECTRICAL ENGINEERS.—*South Midland Centre :* Monday, December 1, 6 p.m., The James Watt Memorial Institute, Birmingham. "The Characteristics and Performance in Service of High Voltage Porcelain Insulators," by Mr. J. S. Forrest (accompanied by a short film). *Wireless Section :* Wednesday, December 3, 4 p.m., Savoy-place, Victoria-embankment, W.C.2. "The Transmission Characteristics of Asymmetric Sideband Communication Networks," by Mr. E. C. Cherry. *Meter and Instrument Section :* Friday, December 5, 4 p.m., Savoy-place, Victoria-embankment, W.C.2. "Maximum Demand Metering : A Study of the Timing and Length of the Integration Period," by Mr. D. J. Bolton. *North-Western Centre :* Saturday, December 6, 2.30 p.m., The Engineers' Club, Albert-square, Manchester. "Outdoor Bushings : Their Construction, Testing and Standardisation," by Mr. W. A. Cook.

ROYAL METEOROLOGICAL SOCIETY.—Wednesday, December 3, 4.30 p.m., 49, Cromwell-road, South Kensington, S.W.7. (i) "Evaporation-Loss per Month Over Drainage Areas, III : Curvilinearity in Relationship to Rainfall of the Same Month and Influence of Previous Rainfall," by Mr. David Lloyd. (ii) "Serial Monthly Values of Mean Temperature Over the British Isles, 1881-1940, and Annual Values, 1866-1940," by Mr. W. H. Hogg and Dr. J. Glasspoole.

CORRESPONDENCE COURSE IN INDUSTRIAL LAW.—The Industrial Welfare Society's correspondence course on industrial law should prove of value to persons entering the labour and personnel-management departments of factories. We are informed that the course does not presuppose previous legal training on the part of those taking it and that the various points are explained in non-legal language. The course consists of six complete discourses on the following subjects : the law of master and servant ; the Factories Act ; the Truck Acts ; trade boards ; employers' liability and workmen's compensation ; National Insurance ; and the law relating to works welfare. The war-emergency legislation on these subjects is also covered. Students will be requested to answer questions submitted to them. Applications to join the course should be made to the Secretary of the Society, 14, Hobart-place, Westminster, London, S.W.1, from whom further particulars may be obtained.

MESSRS. DIXON CORBITT, LIMITED.—We have received from Messrs. Dixon Corbitt, Limited, Teams Rope Works, Gateshead-on-Tyne, a copy of the second edition of *Wire Ropes and Cordage*, a combined handbook and catalogue compiled by Captain D. E. Grant, managing director of the firm, and containing much technical information on the manufacture, use and care of both wire ropes and cordage. The first edition appeared in 1933. The new edition has been practically rewritten throughout, and is prefaced by a short centenary history of the firm, which was founded in 1840, as R. S. Newall and Company, by Lewis Gordon, subsequently the first professor of engineering in the University of Glasgow. The present company is an amalgamation of R. S. Newall and Company with the neighbouring firm of Dixon and Corbitt, in 1887. The former company, in conjunction with one of their managers, John Lang, pioneered the form of wire-rope construction known as "Lang's Lay."

WELDING JIGS AND MANIPULATORS.

(*For Description, see Page* 437.)

FIG. 1.

FIG. 2.

RESEARCH ON LOW-GRADE MANGANESE ORES.

For some time past efforts have been made in the United States to produce metallic manganese on a commercial scale from the manganese ores, most of them of relatively poor quality, which are to be found in considerable quantity in various parts of the country. The object is to lessen the dependence of the United States on imported supplies of high-grade ores, some 97 per cent. of the material used in making ferro-manganese for the steel industry having been imported in 1940. In the same year, the Bureau of Mines commenced building and equipping a research station at Boulder City, near the Boulder Dam, Nevada, the main purpose of which is the investigation of methods of "beneficiating," as it is termed, low-grade manganese and various other ores from Southern Nevada, Arizona and other home sources. The plant is now practically complete and some of the equipment is already in operation, including a 40-ton capacity ore-concentrating unit, a furnace plant, drying and nodulising equipment for ore concentrates, and electrolytic and other metallurgical plant. Dr. R. R. Sayers, the Director of the Bureau of Mines, has recently issued a statement in which he announces that a definite step forward has been made in an investigation on Southern Nevada manganiferous ore, which, we believe, is in the 10 per cent. to 35 per cent. manganese class. Dr. Sayers states that a hearth furnace of the muffle type, developed for the recovery of lime in sugar refining, has been employed with marked success for carrying out the roasting of the ore, under reducing conditions, preparatory to treatment by electrolysis. Apparently, almost any available reducing material, such as crude oil, gas or coal, may be used in the roasting operation, and as much as 98 per cent. of the manganese present in the material treated is extracted in the final electrolytic treatment.

Dr. Sayers adds that, prior to the introduction of the new furnace process, ores containing soluble carbonates were subjected to electrolysis without a preliminary roasting, but the yield of manganese was much lower than is the case when using the new treatment. The Boulder City furnace plant consists of ten hearth furnaces, each 6 ft. in diameter, and together capable of treating 25 tons of ore a day. The fact, however, that furnaces of this type, 20 ft. in diameter and 80 ft. in height, are at present in use in the sugar industry, is indicative of the lines along which further progress may be made if the process proves economically successful. The Bureau is, therefore, continuing its researches on the roasting process to determine the best conditions of operation for various ores and also to obtain detailed information regarding costs. The furnace plant will also be employed for the investigation of several other methods of producing metallic manganese, including the decomposition of manganese sulphate.

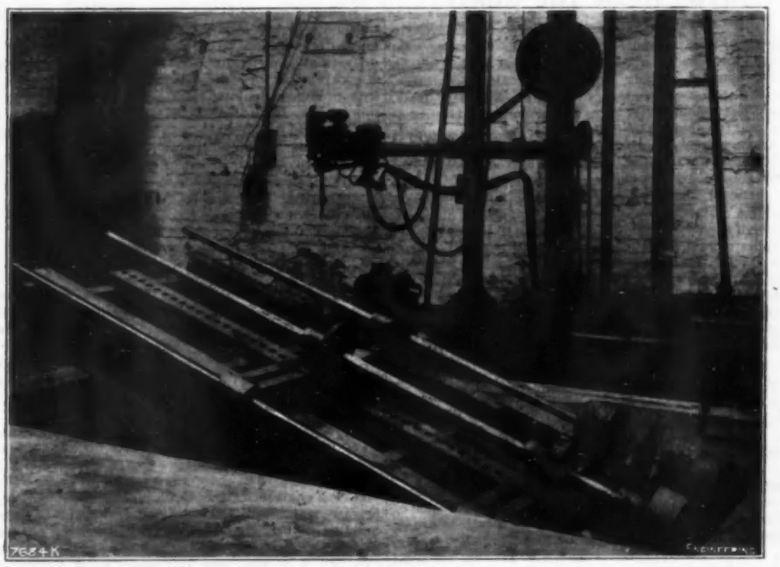


FIG. 3.

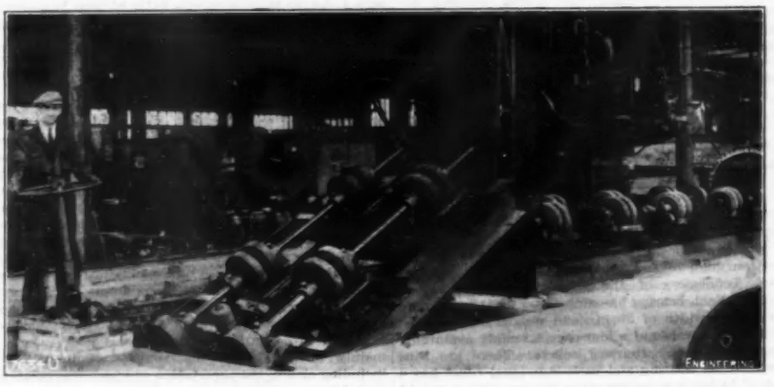


FIG. 4.

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ENGINEERING

FRIDAY, NOVEMBER 28, 1941.

VOL. 152. No. 3959.

PROBLEMS OF REFRIGERATED RAIL TRANSPORT.

AMONG several lines of research and development by the British railways that have been retarded by the war, one of the most regrettable, on account both of its potential value to the public and of the technical problems entailed, is that directed to the refrigeration of perishable foodstuffs in course of transport. The need for such traffic in this country has been a good deal less urgent than in America or in Continental Europe, mainly for the reasons that British summers are cooler and the duration of freight-train transits shorter. These factors combine to make the time occupied in transport a relatively small proportion of the intenral between production and consumption, and the associated deterioration often slight by comparison with what takes place during wholesale and retail distribution. At the same time, the improved quality of fresh food resulting from even a moderate degree of refrigeration during rail transport has been appreciated of late years both by the public and by traders. Moreover, once a start was made with railway refrigeration, many possibilities of developing new traffics became apparent: traffics, for example, in highly perishable commodities like milk or fish, over much longer distances than had previously been possible; transport of frozen foodstuffs which must be maintained at low temperature between cold stores; rapid disposal of selected first-quality produce for the growing British canning industries; and transport by sea and rail of fresh food of Continental origin.

With the resources open to engineers, the conveyance of perishables in the best possible condition would present few technical difficulties if expense were no object. It is precisely this latter aspect, however, that raises the most serious problems in this country, where the quality of non-refrigerated produce is usually good enough to be keenly competitive. It may be recalled that Mr. F. C. Johansen, when he opened an informal discussion on "Railway Refrigeration Problems" at the Institution of Mechanical Engineers in May last, indicated that refrigerated rail transport in this country is profoundly influenced by economic considerations. This was substantially confirmed by the ensuing discussion, and illustrated by varied examples drawn from his experience over a number of years in the Research Department of the London Midland and Scottish Railway. The development work of that railway, fully representative of the British railways as a whole, embraces a surprising diversity of commodities ranging from meat and fish to fresh fruit and cut flowers, and each type of traffic requires special consideration from the physical and biological standpoints. Underlying all of them, however, is the general problem of transportation with the best overall economy; paying regard, on the one hand, to the extent to which the quality of the product is improved and its selling price enhanced by alternative degrees of refrigeration and methods of treatment at all stages of railway handling; and, on the other, to the costs of insulated vehicles and refrigerants, to the duration of journeys, and to the means available for operating and manipulating the traffic.

These and other similar factors bear significantly upon the technical methods that have been tested by the railway research staffs and subsequently adopted. Indeed, if there existed a sufficient demand in this country for refrigerated rail transport, an obvious way of meeting it would be to run complete trains of insulated vans, each fitted with cooling coils and a separate thermostat to control temperature within limits suitable for different commodities, and each supplied with liquid coolant circulated from a single power car containing a large compression refrigerator and auxiliaries. A system embodying this principle is almost certain to figure among post-war developments in America, since already something not unlike it exists in road transport. Alternatively, the large van, individually refrigerated by a petrol- or Diesel-driven compressor, which has been extensively used abroad, could be made a paying proposition here if traffics were sufficiently large and regular. The pre-cooling of railway cars can also be greatly simplified and done more efficiently on a large scale. The problems encountered are much the same as those of cold storage on land, for which excellent solutions have already been achieved.

For railway refrigeration, on the scale hitherto possible in this country, land practice has little assistance to contribute beyond the broad principles underlying thermal insulation and temperature control. The railway van or container, subject in service to shunting or lifting strains, presents many structural difficulties when thermal insulation is a major objective. The insulating material is preferably of light weight and low thermal capacity and, therefore, without useful structural strength, while doors occupy a large proportion of the wall area. Nevertheless, metallic connections between inside and outside have to be avoided on account of their high thermal conductivity; and doors must be, and must remain, airtight because air leakage—to which a railway vehicle is much more subject than a stationary cold chamber—introduces not only the specific heat of the air but the more serious latent heat of its moisture content. Air currents due to leakage into the insulation space are a further source of heat loss. Thus, the problem of constructing a light yet adequately strong vehicle, effectively comprising two separate leak-proof chambers, one within the other, is something to tax the ingenuity of a railway's mechanical engineers. A notable feature of vehicles of proved design is the use of metal-clad plywood for the surface panels. Soldered joints lead to perfect airtightness, while the non-absorbent internal surfaces make for that cleanliness which is essential in the conveyance of foodstuffs.

Most of the development work on British railways has been carried out, for the reasons outlined above, upon vans or containers of nominal capacities up to about 10 tons, a full load of refrigerated food being generally less than half this nominal figure. Separate refrigeration of individual vehicles has been the almost universal practice, the materials employed being water ice, with or without admixture of salt, or solid carbon dioxide; the choice being governed to some extent by convenience or by the degree of refrigeration required, but always with cost, and the amount which traders have been prepared to pay, as the controlling factors. Traffic in wet fish, for example, from ports where ample supplies of cheap water-ice are available, is an obvious case for ice-salt refrigeration, and the associated problems are the eminently practical ones of deter-

mining the proper quantities of refrigerant in relation to the size of the load, the duration of the journey, and the seasonal temperature. In these and other matters, such as the value of paper wrappings for boxed fish, the co-operation of the railway companies with the Torry Research Station at Aberdeen has proved of mutual benefit.

Physical problems of rather more interest arise when solid carbon dioxide is used for refrigerating. In the first place, the lower temperatures attainable and the relatively high cost of the so-called dry ice increase the importance of the thermal capacity and insulation of the vehicle. A good deal of valuable work has been carried out, accordingly, to determine these properties in relation to alternative structural designs and insulating materials, the co-operation of the railways and the Low-Temperature Research Station being again mutually beneficial. Apart from its cost, dry ice is preferable to water ice in almost every respect, and there is ample justification for the experiments that have perfected the form of bunker in which blocks of solid carbon dioxide can now be relied upon to absorb heat at the uniform rate desired. Its cleanliness and convenience in use, often in sharp contrast with the corrosive effects of water ice-salt mixtures, are of monetary value, while the fact that it can be transported with little loss in specially insulated containers for use at remote places has proved very serviceable in promoting the refrigerated transport of milk, fresh fruit and cured fish. The effects of the gaseous carbon dioxide which comes into contact with highly perishable commodities has been carefully studied, the general result being to establish that, while the gas may sometimes be discernible to the taste, there are no permanent ill effects, the preservation being, in fact, if anything improved by the low-concentration gas storage.

These results are of considerable future importance to two valuable home industries. An actual experiment with soft fruit, which was canned after refrigerated rail transport in a dry-iced container, showed that no deleterious effects ensued even when several months elapsed before the can was opened. Thus, the enhanced proportion of soft fruit in suitably first-rate condition for canning after transport to the factory from the field represents a complete gain, and should do much to further the active co-operation between canners and railways in the post-war years of reconstruction. The case of fresh milk is rather different, for the reason that contact with a gas-laden atmosphere inside the refrigerator van may impart to the milk a slight acidity which actually is not distinguished (though, of course, it could be) from lactic acidity by the analysts upon whose report the milk is accepted or rejected for retail distribution. Such absorbed carbon dioxide is expelled by pasteurisation and, far from being at all injurious to health, probably somewhat improves the preservation of the milk. However, the exclusion of the gas from milk carried in cans with loose-fitting lids was achieved, either by enclosing the tops of the cans in Cellophane wrappings, or by making the dry-ice bunkers suitable for external charging, the gas evolved being piped from the bunkers into the insulation space. Some admirable milk vans embodying this principle of excluding gaseous carbon dioxide from the interior have been built by the L.M.S. Railway and are technically very successful; but for profitable use they need a regular traffic in sufficient quantity to provide full loads. Thus the influence of economic considerations upon refrigerated rail transport is again exemplified.

And so it has proved, also, with numerous other technically successful solutions of railway refrigeration problems. Eutectic inserts fashioned into milk-can lids are excellent, but they cannot be made to pay on a small scale. Meat can be successfully refrigerated by blocks of dry ice hung in perforated containers among the sides or carcases, but it cannot be a paying proposition unless the meat as marketed commands a higher price. It is with these general considerations in mind that the Research Department of the L.M.S. Railway have been engaged for some time in developing an absorption type of refrigerating apparatus, suitable for fitting to insulated vehicles of fairly small size. The agents employed are ammonia and calcium chloride, and the action is intermittent, the ammonia being dissociated from the calcium chloride by heat and condensed by external cooling pipes, whence it passes to an evaporator inside the van. The refrigerating operation is inaugurated by thermostatically-controlled valves which substitute cold water for the heating steam. The consequent re-absorption of ammonia by the calcium chloride produces rapid evaporation of the liquid ammonia in the evaporator coils, and the load is thereby refrigerated. Underlying the whole project has been the endeavour to produce a refrigerator van of general utility demanding a minimum of maintenance and actuated at almost negligible cost by low-pressure steam from the carriage-warming supply normally fitted to all locomotives. These are the factors upon which the commercial success of the new type of van will devolve, in competition with mechanical compressor-type machines or existing well-tried methods of refrigeration by water ice or solid carbon dioxide. Nor is its eventual adoption on a large scale entirely a matter of costs: it depends also on the expansion of trade in refrigerated commodities. And here, perhaps, is the major justification for a venture of this sort, having so many points of novelty both in principle and in detail of design. Cheap refrigerated rail transport, by filling a present need, will tend to create new traffics, in new commodities and between new centres of trade, and, incidentally, the public will be served by being supplied with food products in better condition. Despite its restricted possibilities in this country, few will deny the value of improved refrigeration in rail transport; and, from this standpoint alone, the efforts of all concerned with the new vehicle deserve every encouragement.

PAPER AND MUNITIONS.

THE war of 1914-18 was the first conflict, we believe, which really qualified for the description of a "paper war"; not merely on the score of the innumerable Notes and other diplomatic communications which passed and repassed in bewildering profusion, but by reason of the quantity of "paper work" which complicated the existence of everyone concerned in it. There are various "establishments" laid down for the quantity of ammunition, food, and other consumable stores with which a warship, or a military unit of whatever size, from a battalion upwards, is required to take with it when on active service, but we do not recall having seen anywhere in such lists an item, "paper, tonnage of"; yet the account books which even a company quartermaster-sergeant had to take with him to the front needed some carrying. But, in that war, paper had not really come into its own as a munition; war was still very much an affair of steel, and brass, and the more expensive kinds of timber. Ammunition boxes were made of walnut; why walnut, we have never heard explained. Towards the end of the war, someone in authority began to see reason, and cheaper timbers were used; but the war was hardly over before stocks of practically new walnut ammunition boxes were being sold for firewood. A North-East Coast workhouse-master bought 50 tons of them for his clientele to chop up.

This is a more expensive war than the last but in a few ways it is being conducted more economically. Ammunition boxes, and many other really useful military stores, are now made from waste paper, as the Press of the country has been telling the public with unwonted unanimity for the past month or more. It is for this purpose, and not to relieve the shortage of paper for printing (for which, in any case, the salved waste is not suitable) that Lord Beaverbrook made his appeal for an immediate 100,000 tons—a total which, large as it appears, represents only about 3 per cent. of the pre-war annual consumption of paper in Great Britain. The progress of the various local collections suggests that a great part of this amount should be forthcoming from domestic sources, but this is a reserve which, once consumed, cannot be replenished while the war lasts. For the regular flow that will be still required, therefore, it is probable that increased reliance must be placed on industrial accumulations. How extensive these are is probably not fully realised even yet by many firms and public-utility undertakings. We should not have thought it possible, had the question been put to us at the outbreak of war, before the paper problem became acute, that the offices of ENGINEERING could contribute over 11 tons of paper to the national collection; yet this has proved to to be the case. Admittedly, this total has been achieved only by the sacrifice of some files of periodicals which, in happier times, we should have preferred to keep for a year or two longer, for possible reference purposes; but the issues concerned can all be consulted in such public reference files as those of the Patent Office (where photographic copies of particular articles can still be obtained), the Science Library at South Kensington, and the libraries of the technical institutions, the value of which has not been so fully appreciated in the past by industry as it has been by research workers.

This is one direction in which firms might look for the quota of waste paper that the national need requires of them. Like all purges, however, it should be conducted with discrimination; and we would suggest once again that, before jettisoning files of periodicals that are not likely to be widely preserved in this country, but which are of technical value, firms or individuals should inquire of the more important public and semi-public libraries whether any particular issues are needed to complete their own sets. This precaution is especially desirable, of course, in the case of Continental publications, though there are some British works of reference, complete files of which are not to be found even in the great national libraries.

There are many other directions, however, in which engineering firms may be able to assist, one of the most promising being the masses of blue prints which are frequently retained as shop records of finished work, even though they may show no departure whatever from the original tracings. The preservation of such prints is very liable to become a habit; and, even if some copies must be kept as records of modifications, they usually represent only a fraction of the prints that are pigeon-holed away because it is no one's particular responsibility to decide their fate. Timekeepers' records, stores issue books, and similar papers of purely ephemeral utility are not infrequently preserved for years after they have ceased to have any real value. Among the more technical publications which are apt to outlive their usefulness may be mentioned proof copies of papers read before institutions, and obsolete issues of British Standard and other specifications, long superseded by revised editions.

While, realising the need for waste paper, we have been glad to do our share in striving to bring it home to those who may not yet appreciate its real urgency, we still feel that Government departments themselves might do much more to set a national example in avoiding the wasteful use of paper. The case, reported in *The Times* on November 25, of the shipmaster who collected 5 tons of waste paper from his holds and 'tween decks after the cargo had been discharged, but was forced to take it to sea and dump it overboard because, if landed, it would have been classed as an "import," for which no authority existed, is a typical piece of official absurdity; but it is not so much worse than some of the waste of new paper that occurs when an all-powerful department decides to set up a publishing organisation. We have recently received a copy of No. 1 of *The Midnight Watch*, the wall-sheet with which, apparently, the whole country is to be placarded in the supposed interests of the fire guards and other civil defence forces. As an example of the wasteful use of paper, it is outstanding. Other departments continually shower upon us, and presumably on other editorial offices also, quantities of notices, memoranda and circulars of no conceivable interest to any engineering journal; in one case, at least, after we had written to request that no further matter should be sent and had received the thanks of the department for doing so. When such official waste persists, it is not easy to persuade the public of the necessity for such drastic economy as is enforced by the Control of Paper (No. 36) Order, the full scope of which they have not yet begun to realise.

NOTES.

The Institution of Mechanical Engineers.

The Thomas Hawksley Lecture of the Institution of Mechanical Engineers, which was delivered on Friday, November 21, at Storey's Gate, St. James's Park, London, S.W.1, proved of as great interest and importance as any of its 27 predecessors. The chair was taken by Colonel S. J. Thompson, D.S.O. (vice-president). Colonel Thompson was supported by the Presidents of the Netherlands and Polish engineering associations and of the Institution of Civil Engineers, and by Mr. T. E. Hawksley, grandson of the late Mr. Charles Hawksley, founder of the lecture fund which was established to commemorate the centenary, in 1907, of the birth of Thomas Hawksley, F.R.S., President of the Institution, 1876-77. Prior to the delivery of the lecture, it was announced that Mr. A. H. Lloyd, B.Sc. (Lond.) had been elected a member of Council to fill the vacancy caused by the retirement of Mr. R. E. L. Maunsell, C.B.E., M.A., and that he would hold office until the annual general meeting of the Institution on February 20, 1942, and would then be eligible for re-election. The lecture was entitled "A Century of Tunnelling" and was delivered by Mr. W. T. Halcrow, M.Inst.C.E., M.I.Mech.E. We commence to reprint it on page 434 of this issue. In introducing Mr. Halcrow, Colonel Thompson recalled that he had had a distinguished career as a consulting engineer in railway, dock, and hydro-electric power works, his experience in the engineering of tunnel construction being probably unique. At the conclusion of the lecture a vote of thanks, proposed by Mr. E. Bruce Ball (past-president) and seconded by Mr. Asa Binns (past-president), was accorded with acclamation.

The Shipbuilding Employers' Federation.

The annual general meeting of the Shipbuilding Employers' Federation was held in Carlisle on Friday, November 21, under the presidency of Mr. J. M. Ormston, the shipbuilding manager of Messrs. Vickers-Armstrongs, Limited, Barrow-in-Furness. In the election of the officers of the Federation for the ensuing year, Mr. H. B. Robin Rowell, director of Messrs. R. and W. Hawthorn, Leslie and Company, Limited, Hebburn-on-Tyne, was elected President in succession to Mr. Ormston. Mr. Louis V. Dunlop, general manager of the Govan yard of Messrs. Harland and Wolff, Limited, who was already a vice-president, thus becomes the senior vice-president; and, to fill the vacancy among the vice-presidents, Mr. F. E. S. Beavan, manager of Messrs. The Barry Graving Dock and Engineering Company, Limited, was appointed. Mr. A. L. Cochrane, joint managing director of Messrs. Cochrane and Sons, Limited, Selby, was elected chairman of the Conference and Works Board, with Mr. F. W. Knight, a director of Messrs. Mills and Knight, Limited, London, as vice-chairman. Mr. Rowell, who has been in charge of the Hebburn yard of Messrs. Hawthorn, Leslie and Company since 1936, served in the Royal Engineers in the last war, and subsequently in the Royal Flying Corps. He carried out the first tests on man-dropping parachutes, used from aeroplanes, and himself designed the casting-off gear. He is vice-chairman of the Tyne Shipbuilders' Association, a vice-president of the North-East Coast Institution of Engineers and Shipbuilders, a member of Council of the Institution of Naval Architects, and a member of the Technical Committee of Lloyd's Register of Shipping, and of the Merchant Shipping Advisory Committee. Mr. Dunlop was shipyard manager at the Greenock shipyard of Messrs. Caird and Company when, in 1915, that firm was taken over by Messrs. Harland and Wolff, and remained in that position until 1928, when he was transferred to Govan as general manager. He has been a member of the Central Board of the Federation for a number of years, and recently has been elected president of the Clyde Shipbuilders' Association. He is also a member of the Council of the Institution of Engineers and Shipbuilders in Scotland. Mr. Beavan, the new vice-president of the Federation, was president of the Bristol Channel Ship Repairers' Association in 1933, and again in 1940 and 1941. He was appointed, in 1923, manager of the Barry works of Messrs. Elliot and Jeffrey, Limited. Later, he became manager of the Mountstuart Dry Docks at Barry and, following the ship-repairing amalgamation of 1931, manager of his present firm. Mr. Cochrane is the eldest grandson of the late Mr. Andrew Cochrane, who founded the firm of Cochrane and Sons, and has spent the whole of his professional life in the family business. His vice-chairman on the Conference and Works Board, Mr. F. W. Knight, is a former apprentice of the late firm of Humphrys and Tennant, Limited, Deptford, and subsequently was assistant manager at the Ardrossan Dockyard.

The British Standards Institution.

An important alteration in the administrative organisation of the British Standards Institution was decided upon at the meeting of the General Council, held on November 10, in view of the continuing expansion of the work of the Institution and the development of its relations with Government departments and with the various standardising authorities overseas. In place of the former Chairman's Advisory Committee, it has been decided to appoint an Executive Committee with a whole-time chairman, whose function will be to keep all the activities of the Institution constantly under review, and to report upon them to the General Committee as may be necessary. Unless otherwise determined by the General Council, the new Committee will comprise the chairman of the General Council, *ex officio*; the whole-time chairman (who shall not, *ex officio*, be a member of the General Council); the chairmen of the four Divisional Councils, and of the Finance Committee and the Mark Committee; a representative of the Department of Scientific and Industrial Research; a Government representative (if the Government so desire); a nominee, by the Institution of Civil Engineers, on behalf of the institutions which founded the original Engineering Standards Committee; and not more than three co-opted members, "with the experience of industry and of the work of the Institution," who are to hold office for three years. Mr. C. le Maistre, C.B.E., is appointed the first whole-time chairman of the Committee. Subsequent appointments to that office will be made by the General Committee after hearing the recommendation of the Executive Committee. Mr. P. Good, C.B.E., is appointed Director and Secretary.

The Select Committee on National Expenditure.

The 26th Report of the Select Committee on National Expenditure, for the 1940-41 session of Parliament (the 40th to be published since the Committee was set up) consists of a review of their work and that of the various sub-committees during the session. The main Committee and the sub-committees have held a total of 418 meetings, including 50 visits to establishments under Government control or private management, and have examined 744 witnesses. They have made 25 reports to the House of Commons and, under the powers conferred on them, have addressed two memoranda to the Prime Minister for the consideration of the War Cabinet. The sub-committees number eight, including the Co-ordinating Sub-Committee, which held several joint meetings with other sub-committees to discuss matters relating to the fighting and Supply Services, and, in the early part of the session, devoted considerable attention to contract procedure. The other sub-committees dealt with Army, Navy and Air Services; Supply Services; Home Defence Services; Trade, Agriculture, and Economic Warfare; and Transport Services. Among the establishments visited by the appropriate sub-committees were the headquarters of various Commands, and a number of defence works, camps, training centres, etc.; two of H.M. dockyards, ten private shipyards, the Royal Naval Torpedo Factory, and three of the smaller naval bases; certain stations of the Royal Air Force, two aircraft factories, and an aerodrome under construction; a number of munition factories, Government and private, some of which were in operation and some under construction; and the most important port undertakings, and various shipyards engaged on mercantile ship construction and repair. The general impression conveyed by the summary is that the Select Committee have taken full advantage of their wide terms of reference, and have organised their extensive activities well. From the nature of their work, it is obviously impossible to make any quantitative assessment of the results obtained, but there is no doubt that they have been instrumental in correcting many anomalies.

A Pioneer of Technical Education.

On December 1 occurs the centenary of the death of Dr. George Birkbeck, the chief promoter of the old mechanics' institutions and the founder of the present Birkbeck College, London. Birkbeck was perhaps the most important of a group of reformers who, at the beginning of the Nineteenth Century, when the education of the poorer classes was sadly neglected, did their utmost to bring a knowledge of science within the reach of all. A Yorkshireman by birth, the son of a Quaker banker and merchant of Settle, Birkbeck was born on January 10, 1776. He studied medicine in Leeds, London and Edinburgh, and when 23 years of age, having taken his diploma, was made professor of natural philosophy in the Anderson College, Glasgow. Here, in 1800, he advertised a class "solely for persons engaged in the exercise of the mechanical arts, men whose education in early life has precluded even the possibility of acquiring the smallest portion of scientific knowledge." His class was most successful. In 1804, he removed to London and, while practising in the City, became associated with many liberally-minded men and with various projects for the diffusion of knowledge. One of these was the London Institution, founded in 1809. The classes he had started in the north led to the inauguration of the Glasgow Mechanics' Institution in 1823, and then came the proposal for a similar institution in London. This received Birkbeck's whole-hearted support, and the London Mechanics' Institution, with Birkbeck as president, began work in 1824 in a chapel in Monkwell-street, London. Like other such movements, it had its opponents, and one paper declared that "A scheme more completely adapted for the destruction of the Empire could not have been invented by the author of evil himself." In 1825, however, the Duke of Sussex presided over a successful opening ceremony and the Institution was fairly launched on its career. Its influence was widespread; there were soon thirty other bodies like it in London, while others arose in the provinces and in France, America, Holland and Australia. By 1850, there were some 700 Mechanics' Institutions.

The New Zealand Government Railways.

The annual statement by the New Zealand Minister of Railways (the Hon. R. Semple) for the financial year 1940-41 shows that the gross revenue, 11,160,218*l.*, was the highest in the history of the Department, exceeding by 9·42 per cent. that of 1939-40. The number of passenger journeys was 26,276,923, and freight traffic amounted to 659,724,000 ton-miles. The road services of the Department contributed an additional 7,730,678 passenger journeys. Of the 391 road vehicles, 19 have been fitted with gas producers. The construction of new railway lines was retarded by shortage of staff and by adverse weather conditions, but it was expected that the Kirikopuni-Dargaville line would be completed by the end of the year, and that the Westport-Inangahua Junction and Napier-Gisborne lines would be available for traffic early in the New Year. The completion, by the middle of 1942, of the Wharanui-Parnassus line (the northern extension of the South Island main trunk railway), it was stated, is dependent upon the full supply of rails being available when required. Exceptionally severe weather conditions necessitated special repairs on a number of lines, following damage by slips and floods. Bridges completed during the year 1940-1, included a 960-ft. bridge over the Wairau River, near Blenheim; a 242-ft. bridge over the Mangawara River, near Taupiri; a 630-ft. bridge over the Rangitikei River, near Feilding; and a permanent bridge, about 20 miles north of Napier, to replace a temporary structure. The foundation piers of a 2,295-ft. steel bridge over the Waiau River, near Parnassus, and a 520-ft. bridge over the Opawa River, near Blenheim, have been erected, and the steelwork will be proceeded with as material

becomes available. Electrification of the 27 miles of line between Wellington and Paekakariki was completed and the line brought into regular service in July, 1940. The railway workshops have extended their manufacture of various types of small engineering tools, formerly imported, and have been engaged also in constructing machinery and accessories for the treatment of linen-flax fibre. The year's output of new locomotives and other vehicles comprised two electric and ten steam (KA-class) locomotives, 25 passenger coaches, 20 brake vans, and 1,236 goods wagons. One 50-seat Vulcan railcar (the first of ten ordered) was received from England in October, 1940, and was put into service between Christchurch and Hokitika. Two additional railcars for the South Island lines arrived after the close of the financial year. The locomotive-building programme provides for the construction of 15 KA-class and 35 J-class heavy main-line steam locomotives.

LETTERS TO THE EDITOR.

METHOD OF FINDING THE EQUATIONS OF CURVES.

To the Editor of Engineering.

Sir,—With reference to Mr. Barnes' article on "The Method of Finding the Equations of Curves" in your issue of October 24, on page 334, I should like to submit an alternative method for finding the values of the constants in equations of the type

$$y = A + Bx + Cx^2 + Dx^3 + \ldots Kx^n. \quad (1)$$

Firstly, in using the method of successive differences, as explained by Mr. Barnes, we test for a constant difference in the consecutive and evenly spaced values, and should we obtain a constant quantity in, say, the n^{th} differences, it follows that we have found ordinates for a line of constant slope in the $(n-1)^{th}$ differences, and therefore, the equation of this line is readily obtainable. Secondly, by a method of successive integration in which the integral constants of the intermediate equations are omitted, we obtain the values of the constants in the last two terms of the above equation (1), and thence the remaining constants by the substitution of points taken from the primitive curve.

Consider, for example, the primitive curve and its successive differences D_1 and D_2 as tabulated below:—

Primitive.		Derived.	
x	y	D_1	D_2
0			
1	6		
		11	
2	17		6
		17	
3	34		6
		23	
4	57		6
		29	
5	86		

The second differences, D_2, indicate the order of the equation, *i.e.*, a quadratic

$$y = A + Bx + Cx^2.$$

The values of D_1 yield a line of constant slope, and it is observed that

$$D_1 = 11 \text{ when } x = 1\tfrac{1}{2}$$
$$D_1 = 17 \quad " \quad x = 2\tfrac{1}{2}$$

and so on

$$\therefore \quad D_1 = 6x + 2$$

and

$$y = \int D_1\,dx = \int (6x+2)\,dx$$
$$= 3x^2 + 2x + A. \quad . \quad (2)$$

By inspection of the co-ordinates of the primitive curve it can be seen that

$$A = 1$$
$$\therefore \quad y = 3x^2 + 2x + 1.$$

The value of A, the intercept on the y axis, could, if desired, be obtained by the method of extrapolation.

Again, referring to Example I of Mr. Barnes' article, the method of successive differences indicates an equation of the form

$$y = A + Bx + Cx^2 + Dx^3 + Ex^4 + Fx^5$$
$$D_4 = 696 \text{ when } x = 2$$
$$D_4 = 1{,}056 \quad " \quad x = 3$$
$$\therefore \quad D_4 = 360x - 24$$

and

$$\int D_4\,dx = \int (360x - 24)\,dx \quad = 180x^2 - 24x + \ldots$$
$$\int (180x^2 - 24x + \ldots)\,dx = 60x^3 - 12x^2 + \ldots$$
$$\int (60x^3 - 12x^2 + \ldots)\,dx = 15x^4 - 4x^3 + \ldots$$

and

$$y = \int (15x^4 - 4x^3 + \ldots)\,dx = 3x^5 - x^4 + \ldots\ldots$$
$$= 3x^5 - x^4 + Dx^3 + Cx^2 + Bx + A \quad (3)$$

and

$$A = 2 \text{ (given)}.$$

Substituting in (3) from the primitive curve, *e.g.*,

$y = 3$ when $x = 1$ $\therefore$ $D + C + B = -1$
$y = 104$ " $x = 2$ $\therefore$ $4D + 2C + B = 11$
$y = 743$ " $x = 3$ $\therefore$ $9D + 3C + B = 31$.

Solving, $D = 4$; $C = 0$; and $B = -5$.

$$\therefore \quad y = 3x^5 - x^4 + 4x^3 - 5x + 2.$$

It is generally desirable in practice to plot the primitive curve for the purpose of smoothing out any small experimental errors, before attempting to convert the variables into a linear form.

Yours faithfully,
C. J. N.

Gillingham, Kent,
November 18, 1941.

THE CONSTANTS OF STRAIGHT-LINE LAWS.

To the Editor of Engineering.

Sir,—I am indebted to Mr. G. F. Herrenden Harker for the support he gives in your issue of November 21, page 414, to the suggestions made in my recent article under this heading, published in Engineering of October 31, on page 354. May I ask your indulgence to amplify two of the points raised in his letter?

The formulæ there quoted relate to *numerical* departures in x and y. What I had in mind, and should perhaps have stated more precisely, was *fractional* departures, expressed in terms of the respective ranges. For example, in measuring a 10-ohm resistance by voltmeter and ammeter, ranges 50 volts and 5 amperes, respectively, I should regard departures of 1 volt and 0·1 ampere as equally significant. As far as I am aware, this implication is quite usual, and the formula, therefore, requires weighting to be consistent with practical requirements. When this is done, the result, as Mr. Harker correctly points out, is substantially the same as that obtained by the methods I advocate, which besides saving arithmetic have the additional advantage of making the necessary adjustment automatically. The difference between m_x and m_y is never likely to be large, in any case.

I am at a loss to understand the allusion to personal bias, which so far as I am concerned does not enter into the matter at all. My word "casual" in relation to the weighting was used in its sense of "varying with circumstances" (Oxford) to denote that a smooth law was not applicable. As an example of a case in which a 50 per cent. weighting is correct, consider a series of voltage readings which overlap the range-change on a two-range voltmeter, correct to 1 per cent. of full-scale reading. The change is arbitrarily made at some convenient stage, and the probable *voltage* error is clearly doubled on the higher range. Other examples, including temperature measurement by resistance and optical pyrometers, each with characteristic probable errors, could be quoted *ad nauseam*.

There are, of course, cases where weighting should not be used (*cf.* Chap. X of Dr. Norman Campbell's *Measurement and Calculation*, in which Gaussian theory is roundly condemned), but the temptation to dogmatise on these things in general terms is, to quote Mr. Harker, one to be resisted. Each case must be judged on its merits.

Yours faithfully,
G. F. Freeman.

West Ham Municipal College,
West Ham, E.15.
November 23, 1941.

A CENTURY OF TUNNELLING.*

By W. T. Halcrow, M.I.Mech.E.

Tunnelling is probably one of the oldest branches of engineering. Tunnels were driven for various purposes in earliest historical times and one might go back even farther, before the dawn of history, as subterranean galleries and passages have been found in dry chalk, which are ascribed to the work of pre-historic man. The uses of tunnels are many and varied; among the earliest may be cited roads, refuges, storehouses, temples, tombs, aqueducts, and mines. In later times, tunnels were used for canals; railways; conduits for gas, electricity, and water supply mains; sewers; and goods transport (for instance, the London Post Office tube railway). In recent years may be added the many long tunnels driven to serve as gravity or pressure conduits for water-power and water-supply schemes; those for temporary or permanent flood escapes at dams; those driven for the circulating-water systems of large electric generating stations; and tunnels constructed in place of bridges for highways crossing rivers. I have not referred to their application to military purposes; but sapping and mining are arts of warfare of long standing. It is of interest to reflect that the refuge and storage tunnels in chalk, in early days, have their modern counterpart in the air-raid shelter tunnel, the tunnel magazine, the underground aerodrome, and the subterranean oil and petrol storage reservoirs. With certain reservations, however, the purpose of the tunnel does not greatly affect the methods of construction; and as it *is* with the latter that I propose primarily to deal, I shall not differentiate between the uses of the tunnel, but stress rather its nature as affected chiefly by the conditions under which it is built.

An important reservation is that in regard to mine tunnels driven through ground which is not self-supporting. In these, timber or steel is used to prevent falls of the roof or caving-in of the sides, but a certain amount of "give" and deformation is permissible and expected; its prevention is not only unnecessary, but would be prohibitive in cost. In ordinary tunnels, on the contrary, the timbering is generally a temporary structure which is subsequently replaced by a permanent lining that must be capable of supporting rigidly any pressure it may be called upon to bear. Mine tunnels form, therefore, a special class to which I shall not refer further.

I may turn aside for a moment to consider the effect of the advances in tunnelling practice during the century under review and take as an illustration the Metropolitan District Railway—London's old "Underground"—which were opened for traffic in 1863 and 1868, respectively, and subsequently extended. These railways, running through the heart of London, are constructed in the London clay and overlying beds. The lines are laid in a series of deep cuttings supported by massive brick retaining walls, and in cut-and-cover tunnels with brick arches. To have built these railways in deep tunnel by the methods then in general use would, owing to the nature of the soil, have been prohibitive in cost and, in places, hazardous in execution; but, on the other hand, to construct these railways now to the original plans would probably be equally prohibitive in cost, owing to the enhanced value of the land and property to be expropriated. The demand for increased transport facilities in the ever-growing and heavily built-over London area has undoubtedly stimulated progress in the art of tunnelling; and with the development of modern methods of tunnel construction in the London clay, the present London tube system has quickly grown up. This rapid development is equally true of other great cities.

The introduction and growth of the railway generally has given a great stimulus to tunnelling, as did canals to a lesser extent before it; and it is perhaps not entirely a coincidence that the period which has elapsed since the first railway was opened in 1825 does not differ greatly from what I have called the era of the modern tunnel. A large proportion of tunnels are associated with roads, railways, and canals, their purpose being to effect a short cut through, instead of a lengthy detour round, a hill. The advantage of a tunnel is more pronounced in the case of a railway than of a road, owing to the steeper gradients permissible on the latter. In the case of a canal, this is still further accentuated, as the slope of a canal is not only flat, but reverse gradients are inadmissible.

The march of science has led both to an increase in the demand for tunnels, and, at the same time, to improvements in tunnelling methods which have made possible their economical construction in increasing length and size, and have enabled such work to be carried out in more difficult ground. Among these

* The 28th Thomas Hawksley Lecture, read before the Institution of Mechanical Engineers, London, S.W.1, on Friday, November 21, 1941. Abridged.

advances, many of which are associated with mechanical engineering progress, may be mentioned :—

(1) Power drills and improvements in drill steel.
(2) Improvements in explosives.
(3) Mechanical methods of clearing and hauling spoil.
(4) Improved methods of lighting and ventilation.
(5) Use of electricity.
(6) Use of compressed air for tools and plant.
(7) Use of concrete as a lining material.
(8) Use of cast-iron lining.
(9) Methods of pressure grouting.
(10) Use of the shield for tunnelling.
(11) Use of compressed air in tunnelling in water-bearing soil.
(12) Improvements in pumping machinery.

All these and many others have played a part in increasing the rate of construction, in reducing the cost of tunnels, and in enabling them to be built where, with the methods available a century ago, they would have been impracticable. One has only to read an account of the stupendous difficulties met with in the construction of the first Thames tunnel and contrast it with the comparative ease, certainty, and precision with which a tunnel in a similar site is constructed nowadays, to realise what an advance has been made in the art.

Each of the factors indicated in the list above comprises a field in itself. I will confine myself, therefore, to the general principles of tunnelling, and endeavour to trace in outline the progress in the art during the past century, with brief references to a few of the notable tunnels constructed in that period. For this purpose, it is desirable to classify tunnels under four main headings :—(*a*) tunnels in rock and self-supporting ground ; (*b*) tunnels in soft soil, which is not self-supporting ; (*c*) tunnels constructed with the use of shields ; and (*d*) subaqueous tunnels. There is necessarily a certain amount of overlapping between the classes. The strata through which a tunnel passes may vary widely, and one length of it may be in dry soil and another in ground heavily surcharged with water.

Even in hard self-supporting ground, such as rock, water may be met with in considerable quantity from springs or fissures. These must be plugged, or if this is impossible, provision must be made to drain away the water. In softer ground, the percolation may be general, and in such soil as water-bearing gravel it may be very heavy. This introduces difficulties in regard to prevention of slips, as well as those connected with drainage and the construction of the lining. A revolution in tunnelling through water-bearing strata has been effected by the use of compressed air. This enables the internal pressure in the tunnel to be raised above atmospheric pressure sufficiently to balance the head under which the water is flowing. As long as this pressure is maintained, water will be unable to percolate into the tunnel and the work can be executed in the dry. Compressed air is the accepted remedy against water, and it can be used in any type of tunnel and not only in those where a shield is employed. The usual practice is to build a bulkhead in the access shaft or across the tunnel, at a point where the walls are either naturally impervious or have been rendered so by the lining, and to introduce compressed air on the working side until the pressure is raised to the requisite degree. Through the bulkhead an airlock is constructed for the passage of men and materials.

The use of compressed air complicates the process of tunnelling in that the spoil, materials, and men must all pass through the airlock. Excepting occasionally in tunnels of small size, it is usual to provide separate airlocks for men and materials. In the use of compressed air, two limitations arise. The first is the maximum pressure under which the men can work ; this is generally put at 35 lb. to 40 lb. per square inch above atmospheric pressure, corresponding to some 80 ft. to 90 ft. static head of water. The second is the difficulty, in material such as open water-bearing gravel, to maintain the pressure, on account of the great loss of air by leakage. The tendency to air leakage arises from the difference of hydrostatic pressure between the top and bottom of the tunnel. If the air pressure is sufficient to hold back the water at the bottom, then it will be in excess at the top of the tunnel and under this excess of pressure, the air will tend to escape.

Before compressed air was applied to tunnelling it had already been used in the sinking of caissons. Experience of its effects had also been gained in the kindred process of diving, with the bell and with the dress. With the extended use of compressed air in tunnelling, it was found that a great deal of sickness occurred among the workmen, the most serious complaint being that known as " bends " or caisson disease. Medical research revealed that this was caused by the rapid release during decompression of nitrogen absorbed in solution by the blood during the period of working in compressed air, and that attacks were occasioned by too rapid decompression. The precautions to be taken are now standardised, and with their proper observance little trouble is experienced, even when working in comparatively high pressure.

Tunnels in Rock and Self-Supporting Ground.—These tunnels generally require neither temporary timbering nor permanent lining, and the problem resolves itself into one of devising the most economical and expeditious means of excavating the material and removing it. Subsidiary problems comprise the drainage of any seepage water and the provision of adequate ventilation. The difficulties naturally increase to some extent with the length, size, and depth of the tunnel ; but with the mechanical appliances now available no serious limitations are imposed. The ideal material through which to tunnel is compact chalk, as it is easy to excavate and at the same time is self-supporting and generally dry ; but granite or other hard rock presents little difficulty with modern drilling machines, provided that it is sound and free from water-bearing fissures.

Until comparatively recently, most of the long rock tunnels were constructed for railways, as notably those through the Alps. With the rapid growth of water-power development since the beginning of the Twentieth Century, many long tunnels have been driven as gravity or pressure conduits ; similar tunnels have also been constructed in connection with the water supply of great cities. Since time is an important factor

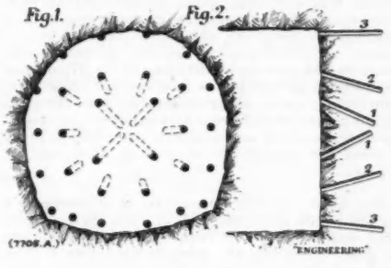


TABLE I.—Weekly Rate of Advance for Tunnels in Rock.

Tunnel.	Date of Completion.	Length, Miles.	Approx. Area, sq. ft.	No. of Working Faces.	Average Progress per Face per Week, ft.
Hand drilling :—					
Average of a number of European double-track railway tunnels, driven with hand-drilling and black powder	—	—	530	—	6·5–12·5
Average of a number of American tunnels	—	—	—	—	9–16
Mont Cenis	1870	8	530	2	12
Power drilling :—					
Mont Cenis	1870	8	530	2	32
Hoosac, U.S.A.	1873	4·6	259	4	16–30
Simplon	1906	12·5	250	2	96
Shandaken, N.Y.	1922	18	110	12	91
Florence Lake, California	1925	13	211	6	125
Lochaber (Ben Nevis)	1930	15	170–190	22	91 (max.)
Hetch Hetchy, California (rock section)	1934	6	168	6	75–100
Garry (Grampian), Scotland	1937	5	62	2	121
Seilich (Grampian), Scotland	1939	4·5	62	2	112
Haweswater, Yorkshire	1933	4·9	81	2	127 (234 max.)
Yewbarrow, Yorkshire	1931	0·8	81	2	127 (220 max.)
Colorado River Aqueduct :—					
7 tunnels	1938	23	250	—	118–173 dry
5 tunnels	1938	45	250	—	41–150 wet
Delaware Water Supply	1940	—	270	—	120 hard rock, 250 shale
Cripple Creek, Colorado	1939	6	72	1	340

in such work—which forms only a section of the whole scheme—much attention has been paid to expedition, and the result is a marked progress in the science of rock tunnelling.

The driving of a rock tunnel comprises three operations : (1) drilling, (2) blasting, and (3) removal of spoil, and it is the third of these which now mainly governs the rate of progress. A hundred years ago, the holes were hand-drilled with hammer and bar, and after blasting the spoil was hand-loaded into wagons and hauled by man or animal power. The old method of hand-drilling may be said to be now entirely superseded by power drilling in tunnels of any appreciable length. The rate of driving that can be effected with power drills is in advance of hand-clearing (for which, in its turn, mechanical devices have been adopted), and it is on the efficiency of these operations that the rate of progress of the tunnel now principally depends. Mechanical plant for clearing the spoil entails a certain minimum cross-section of tunnel, and it is sometimes expedient to increase the area above that required for its actual purpose, so that suitable plant may be installed and the speed of driving increased. While the method of excavation varies with the class of tunnel, the removal of the spoil is much the same in every case.

The minimum size to which a heading can be conveniently driven is about 5 ft. by 6 ft. If the section is not greatly in excess of this, the tunnel can be driven to its full size at once. Where it is considerably larger, the usual practice is to drive a heading in advance of the main tunnel, following this up by widening it out to the full section. This heading may be placed centrally, or at the top, or at the bottom of the section. American practice, which is extensive as regards long tunnels in rock, generally favours a top heading with a bench, the length of which may be one and a half to two times the width of the tunnel. The heading and bench are drilled simultaneously and are usually blasted consecutively, the heading before the bench. The bench is then cleared to enable drilling to be resumed, and while this is in progress, the main spoil is cleared and evacuated through the nearest adit or shaft. Recently there has been a trend towards excavating the tunnel to its full section without driving a heading. The operations of excavating and clearing are carried out alternately. This method was employed on the tunnels of the Colorado River Aqueduct and the Delaware Water Supply Scheme, which were 18 ft. and 19 ft. 6 in. in diameter, respectively.

In drilling the heading, the holes are placed at an angle to the face, the object being to cut out a central wedge which the rim or outer holes will enlarge to the full size of the heading. For this purpose, the centre holes are generally fired ahead of the rim holes, or, alternatively, a somewhat heavier charge is placed in the rim holes or a stronger explosive is used in the bottom of them. In modern practice, the firing is done electrically. One hole per 3 sq. ft. of face in igneous rock and one hole per 5 sq. ft. in sedimentary rock is the average number required. The cut will generally be about 80 per cent. to 90 per cent. of the depth of the hole (measured square to the face) for short holes, and rather less in the case of longer holes ; but, to attain rapid progress in driving, fairly long holes are necessary. Figs. 1 and 2, herewith, show a typical arrangement for a heading.

It is usual to make the holes at least 6 ft. to 8 ft. long, but in some recent tunnels 14 ft. to 15 ft., and even 20 ft., has been adopted. A limit is, however, set by other considerations, and very long holes are not ecopomical. They involve heavier charges of explosives, a larger amount of spoil to be cleared after each blast, and a larger proportion of holes which may require recharging, with consequent delay. It is important also to adopt a length of hole which is convenient in relation to the shift. To ensure rapid progress and economical work the shifts must be arranged and the operations timed so as to effect a smooth and continuous sequence. The cycle of operations naturally varies with the conditions ; a typical example is as follows :—

Blasting heading and bench	2	hours
Clearing heading	2	„
Setting up columns for drills	2	„
Drilling and clearing	6	„
Total	12	„

The complete cycle is here 12 hours, allowing for a two-shift day. Conditions in some cases might favour a shorter length of hole and a three-shift day.

A hundred years ago, black powder was the only explosive used. It is now entirely superseded by gelignite or similar high explosive. That most commonly used is 60-per cent. low-freezing gelatine, and occasionally stronger, up to 80 per cent. or 100 per cent. Apart from its being a more powerful explosive, it has the advantage over powder that it breaks up the rock into smaller pieces which can be more readily handled.

Liquid air (or liquid oxygen) has been employed as an explosive and has the great advantage of the elimination of blasting fumes. This is, however, discounted by disadvantages, particularly those arising from its volatile nature.

The shape of the tunnel is governed to a large extent by the purpose for which it is required, but some modification may be desirable to facilitate construction. In tunnels for water, a circular shape gives the best hydraulic section, but it is a more expensive and difficult shape to excavate and, further, it involves a "backfill" or other support for the track. It is usual, therefore, to adopt a flatter invert, and to compensate for the reduced hydraulic efficiency by a slight increase of size. A section commonly adopted is the horseshoe, which combines maximum width and headroom with a flat invert.

In driving a long tunnel, the total rate of progress naturally depends on the number of working faces. A short tunnel would be driven from the two ends only; but in driving longer tunnels, intermediate shafts are sunk or adits driven, each of which provides two more working faces. Adits have the advantage over shafts in that they can be driven more quickly and the tunnel spoil can be removed through them without lift. The choice as between adits and shafts, however, depends mainly upon the topography of the country. It is sometimes expedient to take a less direct route for a tunnel at the expense of increasing its length, if this will enable adits or shafts to be put in. Each additional adit or shaft means extra drilling, excavation, and clearing plant, and in the case of the shaft, of extra elevating plant also. The determination resolves itself, therefore, into a question of capital cost against speed of driving, and the ultimate deciding factor is the time available for executing the work. It is not considered advisable, however, to exceed a length of 1 to 1½ miles drive from a single face.

An average rate of progress in rock tunnelling ranges from 4 ft. to 8 ft. per cut, and from 25 ft. to 100 ft. drive per working face per week, according to the conditions, though these rates have in cases been much exceeded. If water is met with, or timbering has to be used, the rate is slowed down. The maximum weekly rate may be considerably in excess of the average, and on seven long American tunnels, the maximum rate ranged from 113 ft. to 184 ft. per week. In the 15-ft. diameter Florence Lake tunnel, California, which was driven in 1920 through granite, and has a length of 13 miles, the end faces were supplemented by two adits, giving six working faces. Eighteen-foot holes were drilled, to effect a large cut. The average progress at each face was 125 ft. a week, so the total progress was 750 ft. a week, or nearly 7 miles a year. In this tunnel, speed of construction was the primary consideration and the cost was high. The record speed for rock tunnelling was made in the Deep Mine Drainage tunnel, Cripple Creek, Colorado, a tunnel 9 ft. by 8 ft. and 6 miles in length. This tunnel, completed in 1939, was in granite and was driven from a single face. A remarkable rate of progress was achieved; the average drive was 49·5 ft. per day, with a maximum of 61 ft. The average rate was thus about 340 ft. a week. The maximum recorded progress in any month was 1,534 ft.

Among recent British tunnels, the 15-mile tunnel of the Lochaber Power Scheme, completed in 1930, was driven through igneous and metamorphic rocks, principally mica schist, from 22 working faces, and the maximum weekly rate of advance at any face was 91 ft. The 5-mile Garry tunnel of the Grampian Power Scheme, driven from two faces, showed an average progress per face of 121 ft. a week and a maximum of 147 ft. The Seilich tunnel, on the same scheme, 4¼ miles in length, was also driven from two faces, and showed an average of 112 ft. and a maximum of 141 ft. per week per face. The two latter were, however, much smaller tunnels. As some indication of the improvement in speed arising from the use of power drills, it may be remarked that the Mont Cenis tunnel was commenced with hand-drilling, the only method available at the time. Power drills were then devised and applied, and the rate of advance was immediately increased 2½ times, even with the somewhat primitive drills used; afterwards, the rate increased to 2·85 times that obtained with hand drilling.

In Table I, on page 435, is shown the comparative rate of advance per face per week for a number of tunnels in rock. A comparison is difficult between different tunnels, as the conditions may vary so widely; but a steady increase of speed is indicated. The most rapid improvement followed, of course, the adoption of power drilling. The average rate for a number of European tunnels, with hand drilling and black powder is shown, as quoted by Drinker.* A similar average for American tunnels shows a higher rate, but some more recent tunnels are included, where high explosive was used.

(To be continued.)

* *Tunnelling, Explosive Compounds, and Rock Drills*, by H. S. Drinker. New York, 1878.

LABOUR NOTES.

As was expected, the recalled National Committee of the Amalgamated Engineering Union, at its meeting in Leicester on Tuesday last week, decided to refer the application for a wage increase of 4*d.* an hour on basic rates to the National Arbitration Tribunal. The resolution adopted was in the following terms:—"This National Committee in no way accepts the specious arguments of the employers, which is in essence a barrier to improved and increased productivity. It emphatically reaffirms the union's demand for an immediate increase of 4*d.* an hour, and instructs the executive to remit the claim immediately to the National Arbitration Tribunal and to open a publicity campaign all over the country in support of the claim."

In the course of the discussion on the resolution, Mr. Tanner, the president, said that the General Council of the Trades Union Congress was not at all satisfied that the unions were getting a square deal from the National Arbitration Tribunal and that the decisions given were based really on the facts of the cases. Mr. Fred. Smith, the general secretary, warned the members of the committee that in starting a publicity campaign they must be careful to ensure that the public did not say that all the engineers were thinking about was how to get more money.

At a meeting in London last week the Central Agricultural Wages Board decided unanimously to raise the minimum wage for agricultural employees to 3*l.* a week. Some time ago, the Board referred to the counties a recommendation that the minimum wage should be 56*s.* a week. Thirty-two of the 47 counties which replied advised the concession of the unions' full claim for 3*l.* a week. All agricultural workers, of course, will not get the full difference between the old minimum rate of 48*s.* and the new minimum rate of 3*l.*, as many of them are already receiving more than the old minimum.

The official cost of living index figure at November 1 was 100 points above the level of July, 1914, as compared with 99 points at October 1. For food alone the index figure was the same at November 1 as at October 1, 65 points above the level of July, 1914, increases in the price of flour having been counterbalanced by decreases in the price of bread. Among items other than food there was a slight rise in the price of clothing and clothing materials averaging between 1 per cent. and 2 per cent. during the month.

Under an arrangement to which the Ministry of Labour and National Service and the Army Council are parties, troops may be sent to aid industry on work of vital national importance where sufficient civilian labour is not available. Employment of soldiers on civilian work will be effected through employment exchanges, which will apply to commanding officers in their districts. In no case will the soldier work parties exceed a fixed percentage of the effective strength of the units from which they are drawn, and commanding officers may refuse to supply troops if they consider the task not to be of national importance or likely to interfere with the military efficiency of the unit. Among the jobs regarded as suitable are unloading coal from railway wagons, clearing mails, moving goods at ports, and helping in sugar-beet factories. The work is to be paid for on a basis arranged by the Ministry of Labour and National Service, but there will be no extra pay for the troops.

In view of the decision of the Amalgamated Engineering Union's National Committee to embark on a publicity campaign in support of the demand for an increase of wages, last week's "token strike" of Clydeside workers was, so far, at any rate, as operative engineers were concerned, an unofficial affair which the war's industry might have been spared. Fortunately, it did not last anywhere for more than an hour, and, naturally, it was only partial. It was "called" by a local shop stewards' council—a body without any official standing.

At the congress this year of the Australasian Council of Trade Unions, criticism was levelled at the formula used by the Commonwealth Statistician, in arriving at the cost-of-living figures upon which the basic wage is calculated, and a resolution was adopted instructing the executive to investigate the matter and take such action as it deemed necessary to maintain a decent living standard for the workers. The delegates also demanded that the trade-union movement should have representation in the Commonwealth Statistician's Department and in the Commonwealth Price-Fixing Commission.

An article in the October issue of the International Labour Office's *Review* states that the first year of the defence programme in the United States, which came to an end in May last, was marked by a significant change in the employment and unemployment situation. There was an increase in employment of over 3,000,000 bringing the total volume of non-agricultural employment to the record level of 38,270,000. At the same time, however, unemployment remained surprisingly high: by May the lowest estimate placed it at over 3,960,000, while another put the figure as high as 9,000,000. The disparity between the rate of employment expansion and the rate of reduction in unemployment has given rise, it is pointed out, to considerable discussion regarding the effect of defence on the employment market and regarding the character of the present problem of unemployment.

In Portugal a penalty of imprisonment for up to one year is imposed on the responsible manager, director, or administrator of an undertaking which dismisses an employee because he belongs to the Portuguese Youth Movement or the Portuguese Legion, or which refuses to take back an employee on his return from compulsory military service or service with the Portuguese Legion. If a salaried employee or worker is dismissed, suspended or punished because he belongs to the managing committee of a trade union, or of an undertaking hampering propaganda for the established social order and for the realisation of the higher aims of the State, the undertaking and the managers, directors or administrators responsible for these acts are liable to a fine.

Under the new South African Factories, Machine and Building Work Act, it is required that "every employer shall grant to every employee employed by him, in respect of each period of 12 months' employment with him and not longer than two month's after the termination of the said period, leave of absence on full pay of not less than two consecutive weeks."

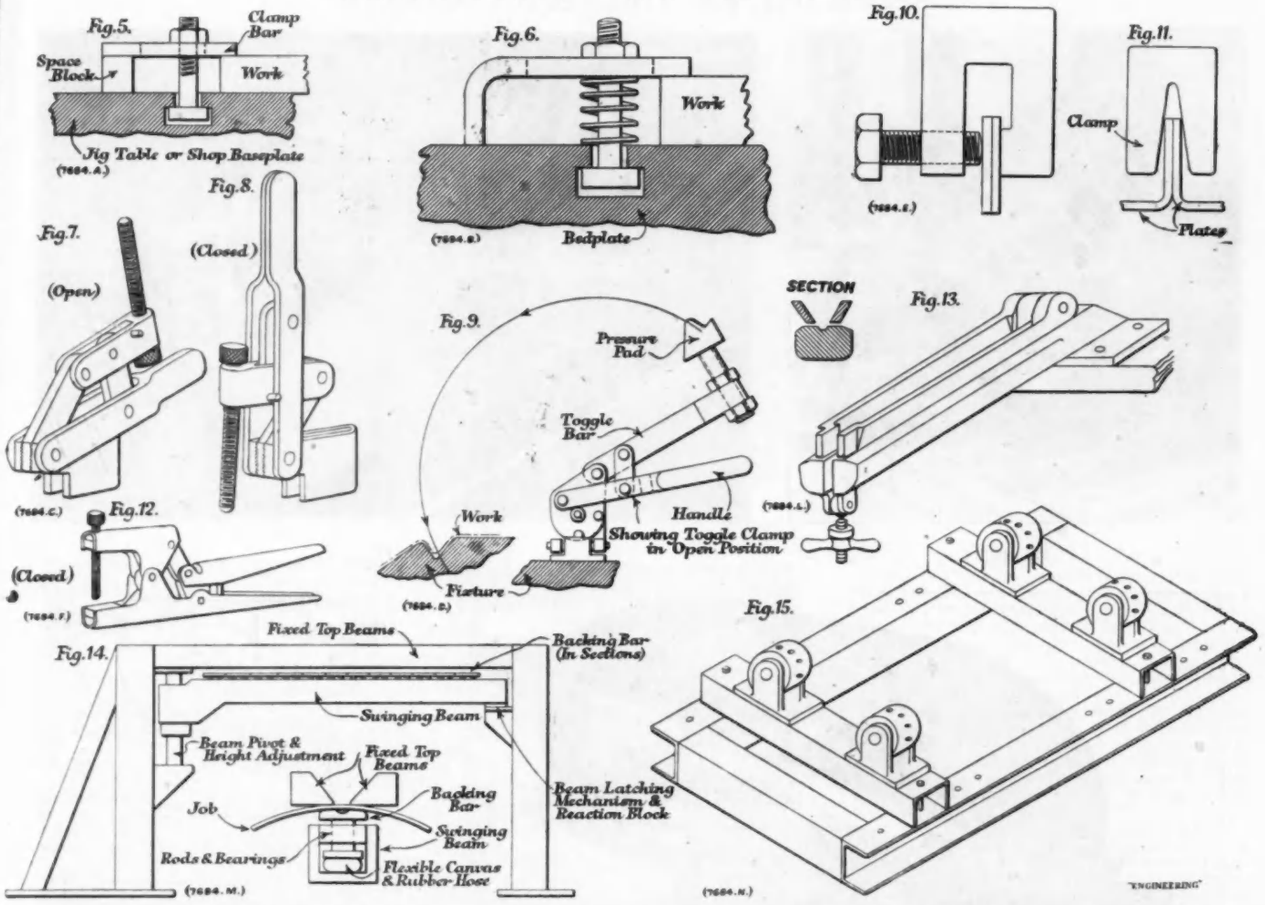
Although the strike of American mine workers has been "called off" and the matter in dispute referred to a conciliation board appointed by President Roosevelt, it should not be overlooked that the word used in the official statement is "suspended." But, presumably, the parties concerned have agreed in advance to accept the finding of the conciliators—whatever it is. The board is composed of Mr. John L. Lewis, president of the United Mine Workers of America, Mr. Benjamin Fairless, director of the Steel Corporation, which owns the collieries involved, and Mr. John R. Steelman, an official of the United States Department of Labour. If the Mine Workers' claim is admitted that only members of their union shall be employed, there may be inconvenient repercussions in other industries, where members of unions affiliated to the American Federation of Labour are employed as well as members of unions affiliated to the Congress of Industrial Organisation.

A MODERN WORKS CANTEEN.—A new canteen was opened on November 18 at the Loughborough Works of Messrs. The Brush Electrical Engineering Company, Limited. The restaurant, which can accommodate 1,200 persons at one sitting, has a floor area of 120 ft. by 150 ft. Gas, steam, electricity and solid-fuel equipment is provided in a roomy kitchen for the cooking and preparation of food.

THE LATE MR. S. C. LLOYD.—We note with regret the death of Mr. Sydney Charles Lloyd, which occurred after a short illness on Tuesday, November 18. Mr. Lloyd, who was chief engineer and sales manager of the Industrial Control Department of Messrs. Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, 17, joined the company on January 1, 1919, as chief engineer and subsequently became also sales manager. His previous career included periods of service with Messrs. Ferranti, Limited; Messrs. Dick, Kerr and Company, Limited, and Messrs. Crompton and Company, Limited. He was elected an associate member of the Institution of Electrical Engineers in 1912.

THE CONTROL OF BUILDING ACTIVITIES.—The Minister of Health has given notice that, with a view to exercising proper control over building and ancillary operations, arrangements have been made whereby, before building and civil-engineering works of a value of 5,000*l.* and over can be started, they must receive the approval of the Ministry of Works and Buildings. All local government authorities, hospital boards and similar bodies are, therefore, asked to take steps to ensure that no such works are commenced before specific approval to embark upon them has been received. These arrangements, however, do not alter the existing procedure regarding the particulars required from authorities concerning schemes projected or in progress.

WELDING JIGS AND MANIPULATORS.



JIGS AND MANIPULATORS FOR FUSION WELDING.*

THE term "jig" is used for an appliance to hold individual parts of a component together in correct relationship for welding. The term "manipulator" is used for an appliance by which assemblies to be welded are brought quickly into the most suitable positions with the minimum of waste effort on the part of the welding operator. In general, the welding operating factor is about 25 per cent., that is, the average welding operator is depositing weld metal about 25 per cent. of his working time, the remainder being spent in assembling, tack welding, turning the work by crane or by man-handling, changing electrodes and cleaning welds. The use of jigs and manipulators can obviate much of this waste and ensure that the operator is depositing weld metal for a higher percentage of his working time. Shops using adequate jigs and manipulators have increased the welding factor to 50 per cent.

Jigs may be used to perform one or more of the following functions:—(1) to hold parts in correct relationship to one another for welding, ensuring uniformity of size, shape and position of components, and avoiding the necessity for tack welds; (2) to control distortion due to the heat effect on the work, by forcible restraint and by dissipating the heat in the jig structure; (3) to facilitate quick and accurate assembly of components; and (4) to reduce the need for highly skilled operators on repetition work.

The simplest form of jig is the clamping device shown in Fig. 5, above. Clamps of this type have the advantage that any thickness of spacing block can be used to suit the work to be clamped, but the operator has three loose pieces to handle—the work, the clamp bar and the space block. The number of parts to be handled can be reduced by welding the spacing block to the clamp bar, or by making an L-shaped clamp bar, but this necessitates a number of clamp bars suitable for work of different thicknesses. Careful planning of shop production can reduce this difficulty by arranging that each group of welders always handles the same class of work. Where space permits, a light spring can be placed under the clamp bar (see Fig. 6) which holds the bar away from the bedplate while the work is being assembled.

Where the design of the work is such that there are spaces between components, it is frequently possible to arrange clamp bars to hold two details simultaneously. Such a clamp should be placed so that it is not necessary to remove the nut and clamp bar to release the work, but a slackening of the nut and swinging the clamp bar through 90 deg. will effect the release. Here again, a spring under the clamp bar will greatly facilitate handling. A threaded handle made from a bar welded to a nut may be substituted for the conventional nut, thereby eliminating the need for a spanner.

Quick-acting toggle or cam clamps effect a considerable saving in time. Figs. 7 and 8, on this page, illustrate a simple form of toggle clamp in the closed and open position. The pressure required on the work is adjusted in the first instance by the adjusting screw (which, in Figs. 7 and 8, is shown through a tapped hole in the clamp arm), and locked with a lock nut. When clamping an awkward section, a toggle clamp as shown in Fig. 9, herewith, can be advantageously used. Adjustment is made by the two nuts shown above and below the toggle bar, because the shape of the pressure pad prevents adjustment by turning the adjusting bar itself. Any form of toggel clamp must be robust and adequate. The mechanism must bend to some extent, and the final pressure is not equal to the maximum pressure. This point should be watched if the clamps have to offer restraint to distortion.

For clamping plates together, a V-clamp (Fig. 11), cut from a plate or bar, can be hammered on to the work; or else a C-clamp (Fig. 10) is used and adjusted by means of a bolt. A much quicker method is by using the form of toggle clamp shown in Fig. 12, also on this page.

When a large number of similar products is being assembled, it should prove an economy to use a combination of toggle clamps and vice, similar to that illustrated in Fig. 1, on page 430. The toggle clamps are coupled, and are operated simultaneously by the hand lever. The vice is operated by the hand-wheel. A vice was chosen to give a very heavy and rigid clamping pressure. The vice jaws are pivoted to allow for slight irregularities in the work. The clamp jaws are easily removable and different sizes of jaws can be used for varying sizes of work.

The welding of longitudinal seams of containers, tubes and similar products can be facilitated by the use of a scissor type of clamp. For short lengths in thin sheet metal, a hand-operated clamp, as shown in Fig. 13, herewith, is suitable. The sectional view shows the grooved backing bar. When the clamp is in use, the groove lies underneath the weld seam and helps to ensure complete penetration. The clamping fixture shown in Fig. 14, on this page, was designed for longitudinal seams on heavy material. Two top clamp bars are fitted, and the backing bar is arranged on a swinging beam to facilitate unloading. In the particular design shown, the backing bar is made in sections and clamping is effected by forcing these sections against the fixed top beams by air pressure in the rubber hose, as illustrated in Fig. 14. Fig. 2, on page 430, shows a jig with 150 details assembled for welding. Note that the entire working table of this jig can be tilted; thus it is a combined jig and manipulator.

Jigs for welded work may be designed either for the mass production of one article or may be adaptable for a variety of articles. In designing them, consideration must be given to the following points:—(*a*) freedom of access to all weld joints; (*b*) effect of welding heat upon the locating members of the jig and upon the component parts of the product being welded; (*c*) ease of loading and unloading the jig, which has a pronounced effect upon the daily output of welding per operator; (*d*) the jig should be so designed that the component parts of the welded product can only be inserted in the correct position, to enable semi-skilled labour to be employed in loading the jig; (*e*) clamping elements should be arranged so that spatter from the welding does not fall upon threaded parts or machined faces;

* *Welding Memorandum No.* 3. Abridged. Published by the Advisory Service on Welding, Ministry of Supply, Department of the Controller-General of Research and Development, Great Westminster House, Horseferry-road, London, S.W.1.

WELDING JIGS AND MANIPULATORS.

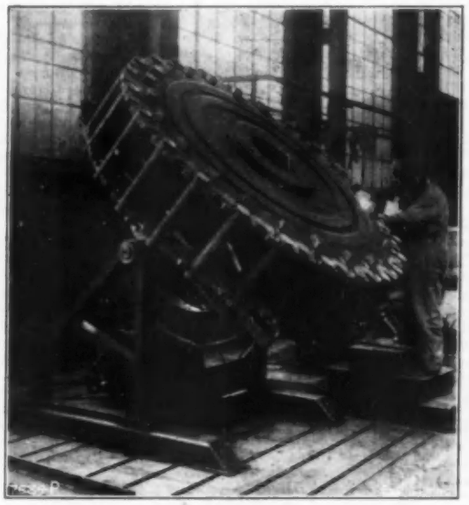


FIG. 16.

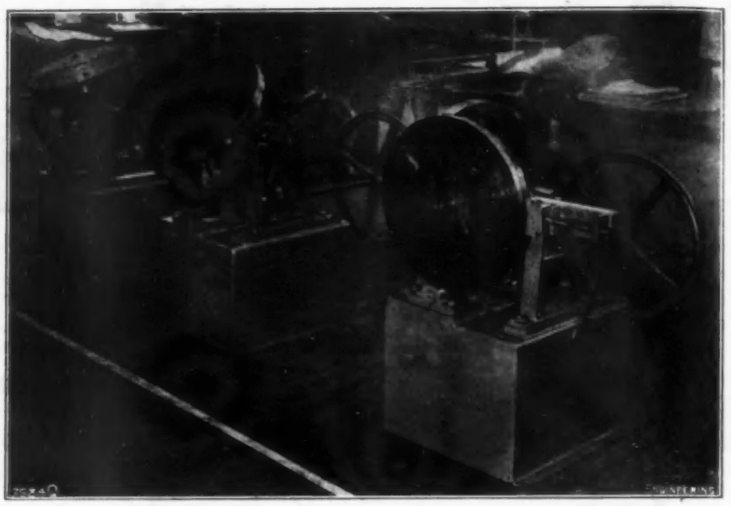


FIG. 17.

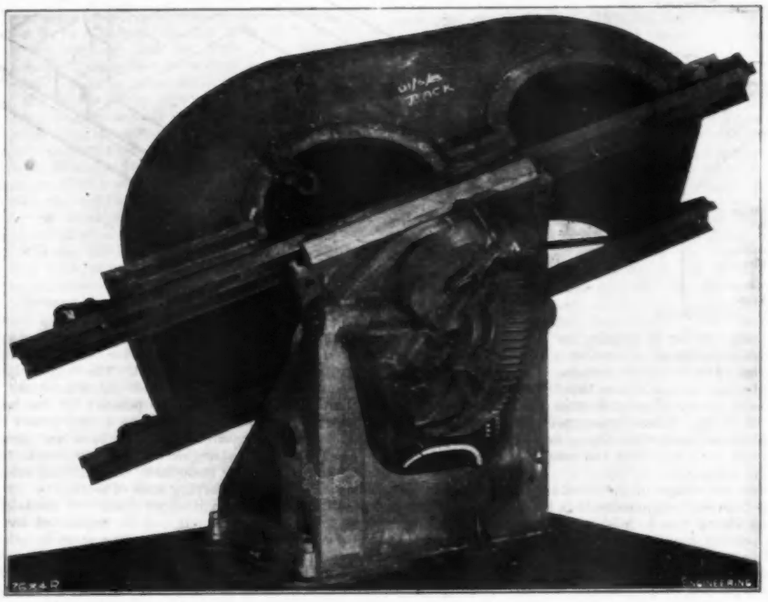
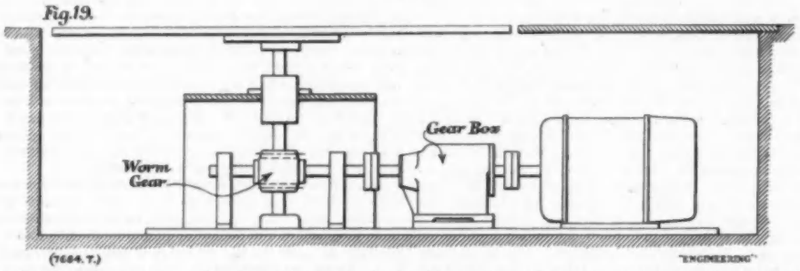
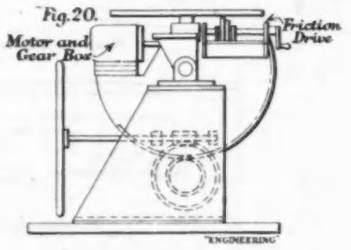
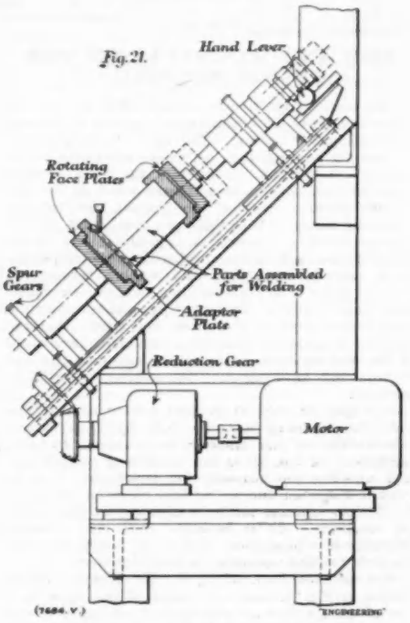


FIG. 18.







(*f*) clamping elements must be arranged so that distortion is controlled; (*g*) clamping elements subject to wear should be made of a hard-wearing alloy or have a wear-resisting alloy deposited by welding; (*h*) assembly of the component parts to be welded should be arranged, so that tack welding is not necessary; (*i*) it should not be necessary to remove the article from the jig until all welding is completed; (*j*) the jig should be designed so that distortion of the component parts during welding does not lock the article in the jig and hinder removal from the jig when welding is completed; and (*k*) if the jig is not designed as a manipulator (*i.e.*, if it cannot be rotated) it should be light in weight to permit easy change of welding position. The behaviour of work in a welding jig is not always predictable, and, in designing and manufacturing a jig, allowance should be made for possible alterations which may be necessary.

Whenever possible, work should be mounted on a device by means of which the welding operator can readily rotate or tilt it into the most convenient position for flat downhand welding. By means of such equipment, a higher daily output of weld per operator is secured. Welding a fillet, for instance, in the tilted position, instead of in the horizontal-vertical position, means that the weld can be completed with, say, one run of a four-gauge electrode instead of three runs with an eight-gauge electrode; that is, in less than

WELDING JIGS AND MANIPULATORS.

FIG. 22.

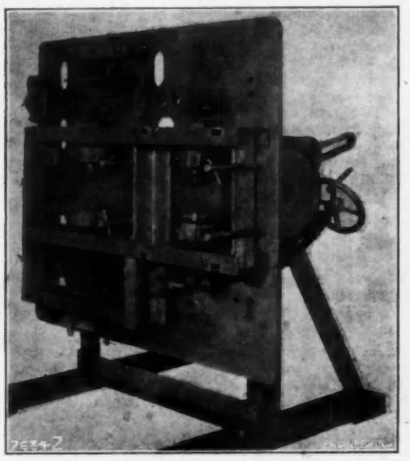


FIG. 24.

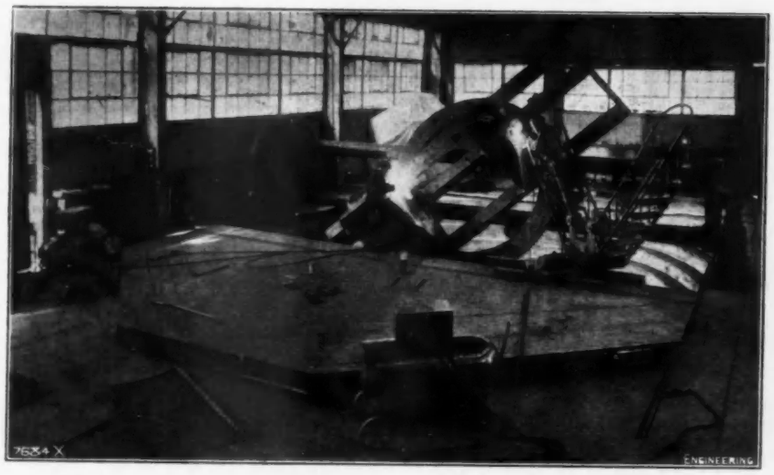


FIG. 23.

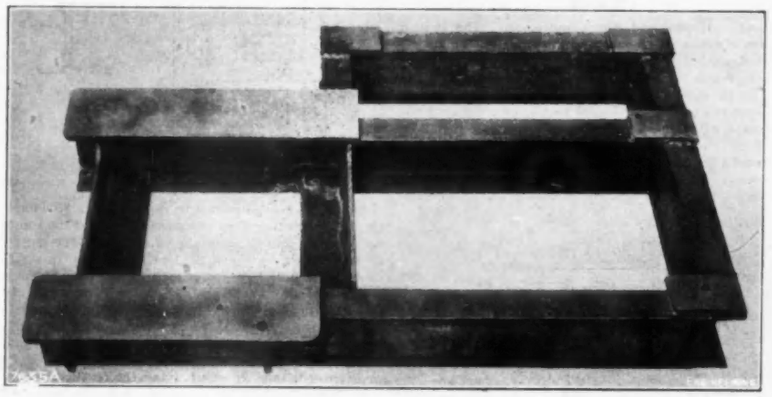


FIG. 25.

half the time, since two descaling operations are eliminated, with less danger of slag inclusion in the weld and less danger of undercut.

An obvious use for turning equipment is in welding the circumferential seams of cylindrical objects, flanges on to pipes, etc. Rollers for this work can be adjusted to accommodate different sizes of job, as in Fig. 15, on page 437, where the two channels on which the rollers are mounted can be located at various points along the base, and the rollers themselves can be adjusted at different points along the cross members. This form of turning device is used for butt joints in all plate thicknesses or lap joints in fairly thin plate. A rotating device of this type is improved considerably by the addition of a variable-speed motor drive. For lap joints in thick plate it is preferable to tilt the work as shown in Fig. 3, on page 430, which shows motor-driven rollers on a tilting table. Speed of rotation is determined by a variable-speed motor with remote control, connected by a flexible cable which can be placed near the operator. Fig. 4, on page 430, shows tilting-roller equipment for welding heavier work. While actually built for automatic welding, this equipment is also used for hand welding.

Manipulators are designed to reduce handling time to a minimum, eliminating the need for labour and cranes, and to save floor space and increase safety by avoiding the need for packing blocks. They should be capable of turning the job at least from the horizontal to the vertical position, and should have adequate locking mechanism to hold the work table in any required position. Fig. 16, opposite, shows an armature frame on a welding manipulator. Fig. 17, on the same page, shows a number of small manipulators suitable for use in welding a variety of different types of work, up to about 15 cwt. Notice the reduction gear for tilting and the handwheel extended on its shaft well clear of the manipulator table, so that free access can be obtained to the handwheel if the job overhangs the table. A brake holds the rotating table in place. In Fig. 18, on the opposite page, the tilting and rotating of the work table are motor controlled. Fig. 19 illustrates a turntable arrangement with the driving motor and gearing below floor level, an arrangement which avoids lifting and keeps work at a level easily accessible for welding.

Fig. 20 illustrates a manipulator with the turntable motor-driven. The drive is by friction, and the speed of rotation of the turntable is varied by altering the distance of the drive wheel from the centre of the plate. The tilting of the turntable is effected by a hand crank through a worm gear. Fig. 21 shows a set-up for welding a cylinder to a circular or rectangular dish. The work is tilted into a convenient position for flat welding. The upper and lower faceplates are driven at the same speed to eliminate possibility of slip between the two component parts at the commencement of welding. Adapter plates can be fixed to the faceplates for different sizes of components.

Two views of a manipulator designed to handle every type of heavy work in a factory are shown in Figs. 22 and 23, on this page. The manipulator is built over a tiered pit. Welding operators can stand on the most convenient tier for welding a given joint. Above the pit are seen parts of the driving mechanism for turning the welding platform through 360 deg. A moving platform, running on rails, can be pushed over the pit if the welding operator is working at a height where this is necessary, as in Fig. 23, or, alternatively, the welding operator can stand on one of the two movable ladders to reach work at a greater height. Complicated types of structure, up to 10 tons in weight, can be handled by this manipulator. The initial cost of the installation, including pit, was over 2,000*l.*, which was recovered in one year by the reduction in welding costs, the equipment being kept working 24 hours a day. As typical of the increase in speed of production effected by the installation, the comparative welding times for fabricating a machine frame may be given. The total length of the welds was 575 ft. The

welding time, with the work mounted on the manipulator, was 77·9 hours; whereas, without the aid of the manipulator, the time taken was 113·4 hours.

Figs. 24 and 25, page 439, show, respectively, part of a base plate assembled in jig ready for welding, and the finished base. The table of the jig revolves through 360 deg. in the horizontal plane and through 240 deg. in the vertical plane. The angle stops are bolted into elongated holes to allow for lateral movement, so that the stops can be moved aside for loading and unloading. In Fig. 24, notice the holes in the table, to permit welding from the reverse side. In general, the use of jigs and manipulators for welded work will speed up production and avoid skilled welders doing work which can be undertaken by unskilled labour.

CATALOGUES.

Industrial Lighting.—A leaflet received from Messrs. Benjamin Electric, Limited, Brantwood Works, Tottenham, London, N.17, illustrates typical industrial lighting installations incorporating Benjamin reflectors.

Steam Separators.—Messrs. James Gordon and Company, Limited, Dalston-gardens, Stanmore, Middlesex, have sent us a leaflet describing the Hagan steam separator, in which a whirling motion is imparted to the steam.

Spark and Dust Arresters.—We have received from Mr. William Alexander, 167, St. Vincent-street, Glasgow, a leaflet describing Vortex spark and dust arresters for the waste gases from Diesel engines and steam boilers in ships.

Shearing Machines.—We have received from Messrs. C. H. Mountford, 68, Nechells Park-road, Birmingham, 7, two leaflets describing the "Nechells" lever shearing machines, the frames of which are fabricated and are claimed to be unbreakable.

Transformers.—We have received from Messrs. Wagner Electric Corporation, 6400, Plymouth-avenue, St. Louis, Mo., U.S.A., a bulletin No. TU-34, describing a new type of transformer, for rural lines, having integral protection against both surges and overloads.

Electric Lamps.—We have received a new price list of the Atlas electric lamps, made by Messrs. Thorn Electrical Industries, Limited, 105-109, Judd-street, London, W.C.1, who guarantee these lamps to have a life of 1,000 hours under normal conditions.

Pistons.—Messrs. Specialloid Limited, Finchley Works, London, N.12, have sent us a list containing particulars of pistons designed for engines converted to use producer gas. These alter the compression ratio, and incorporate a turbulence head shape to increase efficiency.

Electric Drills and Tools.—Messrs. The Consolidated Pneumatic Tool Company, Limited, Fraserburgh, Aberdeenshire, have sent us a catalogue of their Universal electric tools. These include grinders, sanders, buffers, reamers, tappers, screwdrivers and nut runners.

Diamond Abrasives. Dial Gauges.—Messrs. A. C. Wickman, Limited, Banner-lane, Tile Hill, Coventry, have sent us some catalogue sheets describing tools for which they are the sole agents in this country. These include "Neven" metal-bonded impregnated diamond abrasive wheels, the "Diatuf" impregnated diamond dresser, and "Verdict" dial gauges.

Anti-Corrosive Coverings.—Messrs. Wailes Dove Bitumastic, Limited, Hebburn, Co. Durham, have sent us a copy of their Quick Reference Guide for the selection of anti-corrosive coverings, and also particulars of their new product, Bitumastic bitumen-bound water paints. They draw attention, in a covering note, to their new telephone numbers—Hebburn 32321-5.

Switchgear.—Messrs. The English Electric Company, Limited, Stafford, have sent us a brochure which illustrates and describes their cubicle-type switchgear, suitable for any normal high or low voltage system. For switchboards of small size the cubicle housings are constructed of sheet steel, on the unit principle, and for multi-panel switchboards, a fabricated angle-iron framework is employed.

Insulated Cables.—From Messrs. British Insulated Cables, Limited, Prescot, Lancashire, we have received a leaflet describing their paper-insulated cables of the sandwich type. This type of cable has been designed for use in vertical and steeply sloping positions, to overcome the trouble of "bleeding" of the insulating compound, which sometimes occurs with cables of standard construction in such conditions.

Diffusion Pumps.—Messrs. W. Edwards and Company (London), Limited, Allendale Works, Southwell-road, London, S.E.5, who specialise in scientific and vacuum equipment, have sent us particulars of their diffusion pumps for the production of high vacua. One list describes two-stage mercury diffusion pumps, and another deals with the "Mètrovac" type, in which oil is employed as the working fluid.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, etc., of the Communicators are given in italics.

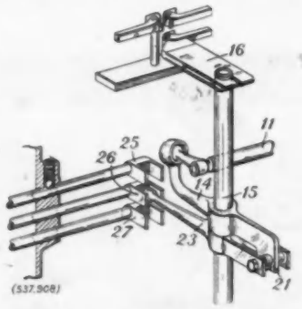
Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C.2, price 1s. each.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

MOTOR VEHICLES.

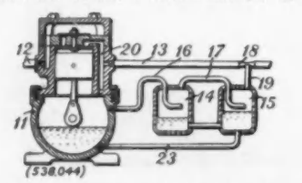
537,908. Gear-Change Mechanism. Lagonda Motors Limited, of Staines, and C. W. Sewell, of Staines. (2 *Figs.*) May 17, 1940.—The mechanism is designed for use with an electromagnetic synchronous gearbox. The shaft 11 is rotated for selecting purposes and can slide axially for actuating a selected striker fork, the shaft being connected by a ball and socket joint to an arm 14 which is fast on a rod 15, at the top of which is secured a contact arm 16 engaging fixed contacts. The arm 14 is formed with a tail 21 which is located between coil springs between the limbs of a fork 23 free to rotate upon the



rod 15, but located axially on it. At its other end the fork carries a ball which engages with the selector forks 25, 26 and 27; 25 is the selector fork for third and second speeds, 26 for first speed and 27 for reverse. In the position shown, the first speed selector is engaged by the fork 23. By sliding the shaft 11 to the right the contact arm 16 energises the electromagnet associated with first speed while the play between the tail 21 and the fork 23 is being taken up. When this play has been taken up the further sliding of the shaft 11 moves the selector fork 26 to the right to engage first speed. The arrangement is such that in each case the switch of the electromagnetic synchroniser is close dbefore a forward speed can be engaged. (*Accepted July* 11, 1941.)

PUMPS

538,044. High-Speed Air Compressor. The British Thomson-Houston Company, Limited, of London. (3 *Figs.*) April 19, 1939.—The invention is a high-speed air compressor employing splash feed lubrication. Normally in such compressors it is difficult to provide for the return of lubricating oil to the crankcase of the compressor after it has once passed the pistons, and there is a tendency to throw oil out of the crankcase and prevent its return from the inlet or suction side of the compressor. The compressor shown has a crankcase 11, an exhaust line 12 and a suction line 13. A conduit



16 connects the crankcase with a first oil-separating chamber 14 above the oil level and a second conduit 17 connects the chamber 14 with a second separating chamber 15 above the oil levels. In the suction line 13 is a Venturi contraction 18. A conduit 19 communicates between the low-pressure region of the Venturi 18 and the upper portion of the separating chamber 15 above the oil level. The suction 13 terminates in an inlet chamber 20, a restricted passage being provided between it and the crankcase for returning any oil which has leaked into the inlet chamber 20. The separating chambers are connected by a conduit below the oil level and the lower portion of the chamber 15 is connected to the crankcase 11 below the oil level by an oil return conduit 23. The operation of the compressor is as follows: Air, as well as oil, may pass from the inlet chamber 20 to the crankcase 11 through the restricted passage which connects them. The flow of air through the Venturi 18 in the suction line causes a reduction of pressure which tends to siphon the air from the crankcase through the chambers 14 and 15 back into the suction line. Consequently there is a continual circulation of air through the circuit during normal operation of the system. If sufficient injector capacity is provided at the Venturi, and if the passages 16, 17 and 19 are sufficiently large and the leakage past the piston is not excessive, there will be a reduction of pressure in the crankcase below that existing in the inlet chamber 20, and any oil deposited in the inlet chamber will be returned to the crankcase through the restricted passage. Due to the vigorous splashing of the oil in the crankcase a considerable quantity will pass through the conduit 16 into the chamber 14, where the oil, to a large extent, separates and falls to the bottom. Any oil that is still entrained is separated in the chamber 15. Whenever the amount of oil collected in the chambers 14 and 15 is sufficient to overcome the pressure in the crankcase, any excess is returned to the crankcase by way of the conduit. (*Accepted July* 17, 1941.)

MISCELLANEOUS.

537,933. Hydraulic Testing Machine. W. and T. Avery, Limited, of Birmingham, and H. Yates, of Birmingham. (4 *Figs.*) March 1, 1940.—The invention is a device which enables the restoring torque of the load indicator to be maintained constant for all ranges of load indication, without the use of lever systems. In the hydraulic testing machine illustrated for tensile, compression, and bending tests, the straining unit incorporates a main hydraulic cylinder arranged between upper and lower crossheads connected respectively to the upper and lower grip holders, the specimen being mounted either between the grip holders or between the lower crosshead and the upper holder according to the test to be made. The cylinder is connected through a pipe-line 11 to a separately housed automatic load indicator 12 having a dial with four concentric charts each covering a different load capacity or range. Between the main hydraulic cylinder and the indicator mechanism are four hydraulic cylinders and rams 17 each having a different capacity which is a predetermined proportion of the main straining cylinder capacity. These ram

Fig. 1.

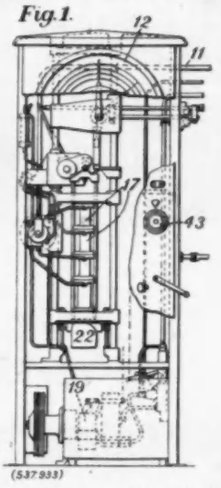
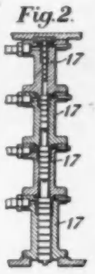


Fig. 2.



cylinders 17 are connected to the load indicator mechanism in such a way that the power factor of the indicator restoring torque remains the same for all the capacities or ranges, irrespective of the load applied to the straining unit. The indicator restoring torque is provided by a pendulum. Hydraulic pressure is applied simultaneously to the main straining cylinder and to the preselected ram cylinder or cylinders by means of a motor-driven duplex oil pump 19. The low-pressure side of the pump is used for quick setting prior to testing, and the high-pressure side is used for applying the test load only. A relatively slow rotation is imparted to the rams within the cylinders 17 by a small electric motor 22 to prevent static friction between the rams and the walls of the cylinders from reducing the accuracy of the test. The load indicator mechanism also operates a stress-strain curve recorder, and is further arranged to switch off the motor driving the duplex oil pump 19 when the maximum load is reached. The rate of straining on the testing machine is pre-set by means of a graduated knob 43 which controls a throttle valve in the circuit between the pump 19 and the straining cylinder. (*Accepted July* 14, 1941.)